DOCUMENT RESUME

ED 082 860 PS 006 964

AUTHOR White, Sheldon H.
TITLE Attentional Processes in Children's Learning. Final Report.
INSTITUTION Harvard Univ., Cambridge, Mass. Center for Research and Development in Educational Differences.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.
PUB DATE Sep 73
CONTRACT OEC-5-10-239
NOTE 91p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Age Differences; *Attention; Attention Span; *Cognitive Development; Complexity Level; *Elementary School Students; Environmental Influences; *Learning Processes; Maturation; Performance; Problem Solving; *Readiness

ABSTRACT

This final report discusses research and literature analyses concerned with the attentional mechanisms in children's learning and analysis of cognitive changes from ages 5 to 7. The long-term objective of the project was to relate knowledge about children's attention and learning to issues of educational practice. The project focused its efforts on conceptual problems involved in formulating the interrelationships among performance, competence, and developmental factors. Major conclusions were (1) There is empirical support for the common emphasis on maturational factors or readiness, (2) Readiness involves performance as well as perceptual and cognitive factors, as in the traditional conception of the importance of attention span, (3) A relationship exists between children's age and ability to solve problems despite noise in the problem field, (4) The complexity of the problem is another important variable on the effects of noise in the problem field, and (5) The interrelationships among attention, cognition, and age can probably be subsumed in Pascual-Leone's mathematical formalizations of Piaget's theory if several modifications are made. (DP)

ED 082860

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

FINAL REPORT

Contract OE 5-10-239

Attentional Processes in Children's Learning

Sheldon H. White

Center for Research and Development on
Individual Differences

Harvard University

Cambridge, Massachusetts 02138

September, 1973

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF

HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

PS 006964

FILMED FROM BEST AVAILABLE COPY

Summary and Conclusions

Research and literature analysis was undertaken to explore the interrelationships among learning, attention, and cognitive change in the 5-7 age range. Project work included: (1) Literature analysis of the body of Piagetian reports of cognitive change at the time of concrete operations; (2) Cross-sectional studies of the coincidence of various behavior changes in American schoolchildren as they move from the preschool to the early school years; (3) Studies of these same changes as they appear in African children living in urban schooled and rural unschooled environments; (4) Studies of these same changes as they appeared in a sample of first graders placed in a transition first grade class for "immature" children; (5) Studies of the developmental correlation between neurological indices and measures of Piagetian conservation; (6) Psychophysiological studies concerned with the hypothesis of a human problem-solving state emerging in development; (7) Studies of the interaction between noise-processing and problem-processing in children's learning; and (8) Experimentation and analysis concerned with the interaction between performance and competence factors in contributing to children's performance in experimental and testing games.

The body of work was designed in an effort to try to get a better overall picture of what appear to be some complex conceptual problems in formulating the kinds of interrelations that must exist between performance, competence, and developmental factors.

Major conclusions deriving from the work may be stated as follows:

(1) One basis for the observed widespread pattern of changes in children in the 5-7 age range must be maturational. There is empirical substantiation supporting traditional notions of a developmental "readiness" for schooling.

(2) It is unlikely, however, that this readiness should be taken solely as a perceptual or cognitive kind of readiness. An important issue is readiness in terms of performance factors. A central performance issue is the question of the ability of the children to elaborate and sustain a program of behavior over time. This question is, probably, the kernel question in traditional notions about the importance of children's attention span.

(3) For a given problem, there is probably a tradeoff relationship between age of children's solving and amount of noise in the problem-field. The more the noise, the older the child has to be.

(4) For a given age, there is probably a tradeoff relationship between amount of noise in the problem-field and the complexity of problem that can be handled. The more complex the problem, the less the amount of noise that can be tolerated.

(5) The interrelationships among attention, cognition, and age envisaged in the course of this effort can probably all be subsumed in Pascual-Leone's recent formalization of Piagetian theory if: (1) his "M-space" and "schemes" are placed in a temporal rather than an abstract framework; and (2) it is assumed that noise-processing and problem-processing compete for the child's finite amount of M-space.

Attentional Processes in Children's Learning

Final Report

The project here being reported was directed at the relationships between children's attentional processes and their learning. The immediate goal of the project was to seek better understanding of the way in which attentional processes enter into and influence children's learning. The longer-term goal of the project was to try to understand attentional factors as they influence learning and cognitive development in the early years of schooling. It was and is our assumption that very significant problems of the arts of teaching, curriculum development, and classroom management reflect questions of how children attend. There are age differences in the way children manage their attention. At any age, there are large individual differences. Schools have to deal with age differences and individual differences and one can estimate that they do so with explicit care and concern. It was felt that an attempt to understand attentional mechanisms and their relation to cognition would inevitably lead to a probing of educational issues. By attention we refer to autonomous, self-guided mechanisms of cue selection by the child. We assume that any child at any moment resides in a very large set of potential 'stimuli' or potential 'information' and that much of the determination of what is seen or used depends upon his choosing. By attention we refer to the individual's selection of available information in the environment and, as will be seen, nontechnical discussions of attention usually refer not to a momentary act of filtering or selection but to a temporally organized pattern of cue usage. By learning, we refer to the development of an organized system of behavior, or a successive series of organized systems, in a milieu that demands a system of behavior to fit specified constraints. This system of behavior is created by organizational processes that are fundamentally designed to be adaptive. The system of behavior includes a response to the cognitive demands of the situation...the formal demands imposed by either the experimental or the school learning milieus...but what we here speak of as learning and/or adaptation implies the regulation of behavior according to not simply the cognitive constraints of the situation but those imposed by social and mood-tension factors as well (White and Fishbein, 1972).

In a general sense, it has always been understood that the way in which children orient and pay attention has a great deal to do with their success or failure in learning. This has been recognized in a number of ways in the literature on experimental studies of children's learning (White, 1963; Stevenson, 1970, 1972). However, as yet, only certain selected aspects of children's attention and orienting have been isolated in either experimental or theoretical analysis. In the more natural milieu

of the school, the issue of how, where, and for how long a child attends has been repeatedly recognized as crucial to his ability to cope with the classroom. Children show significant individual differences in direction and duration of attention. The design and management of classroom procedure must somehow manage to encompass these individual differences. Furthermore, there appear to be significant developmental changes characteristic of all children, particularly in the early years of schooling. Children appear to be able to exhibit more sustained and more strategic patterns of attention as they become older. Conceivably, if we understood the mechanisms at work in the organization of children's attention, we would be in better position to organize classroom environments that would accommodate to age differences and individual differences.

The project was concentrated on two topics that were seen as convergent: (1) attentional mechanisms in children's learning, and (2) the analysis of cognitive changes in the 5-7 age range. These two research lines were partly independent, in that each line required its own appropriate techniques of study, and each required consideration of distinct sets of issues. But both could be seen as directed towards a productive intersection.

The age range between 5-7 years seems particularly significant for the exploration of those factors in children's learning that govern educability. It is in this age range that children typically enter formal schooling and one may suspect that something characterized as "readiness" may be involved developmentally. Turning to the research literature we find that experimental studies of children's learning have repeatedly identified this time of development as a point of distinct change in the child's capabilities (White, 1965). At least some of the changes reported in children's learning at this time seem to reflect changing capabilities for dealing with the variety of stimuli in learning experiments -- i.e., to reflect changes in children's attention (Kendler and Kendler, 1962; White, 1966). Given indications that there are significant changes in learning in this age range, somehow coincident with the readiness for education and somehow coincident with changes in the child's attending, it seemed reasonable to try to confront the complex of related issues in one project.

The Relationship Between Learning and Development: Pretheoretical Issues

The work of the project consisted in a series of empirical studies, literature reviews, and theoretical essays. The most accurate way to describe the thrust of the project would be to characterize it as a series of subprojects directed "pre-theoretical," in the sense in which the notion of "pretheory" has been discussed in the writings of Howard Kendler. A considerable amount of empirical investigation was undertaken. The various studies of children undertaken during the course of the project, the studies to be discussed below, involved well over 2000 children. But an

important part of this research consisted of exploratory investigations, and the kinds of studies undertaken, as well as the reasoning behind the studies, changed from year to year during the project. Similarly, the several literature reviews were undertaken not as ends in themselves but as attempts to explore or clarify particular issues arising in the continuing pretheoretical analysis.

A pretheory is an assumptional structure. A well-known pretheory is something often called "the learning theory point of view." For several decades, psychological discourse about learning was dominated by various learning theories and data organized around the learning theories. The learning theories were a matter of much concern to the psychologists of the 1930's and 1940's and much time and effort was expended in theoretical or experimental efforts to determine whether Tolman or Hull or Skinner was on the right track. Interest in the learning theories has waned by now, although they are still written about and a newer, somewhat more elegant and somewhat more modest, incarnation of the learning theory movement still lives in the form of the mathematical learning theories (Hilgard and Bower, 1966). With the passage of time, the learning theories have come into disfavor, and it has become distinctly fashionable nowadays to produce denunciations of learning theory, behaviorism, or stimulus-response analysis. However, a great deal of our discussion of learning and education implicitly adheres to the essence of the learning theories even today. There was an assumptional structure developed before the several specific theories of learning, that was common to all of them, and that today still exists in psychological discussions of learning for want of a better one. We can call this the "learning theory point of view," and we can estimate that it includes assumptions such as the following:

1. The environment may be unambiguously characterized in terms of stimuli.

2. Behavior may be unambiguously characterized in terms of responses.

3. A class of stimuli exist which, applied contingently and immediately following a response, increase it or decrease it in some measurable fashion. These stimuli may be treated as reinforcers.

4. Learning may be completely characterized in terms of various possible couplings among stimuli, responses, and reinforcers.

5. Unless there is definite evidence to the contrary, classes of behavior may be assumed to be learned, manipulable by the environment, extinguishable, and trainable (White, 1970a).

This set of assumptions, or some set very much like them, forms the traditional nexus for discussions of learning and is still very much predominant in our contemporary discussions. There are alternative pretheoretical systems extant in psychological discussions today, but these

pretheoretical systems have not been developed in such a way as to produce a formed, articulated statement about learning. The Piagetian genetic epistemology clearly offers rival propositional elements, the American information-processing approach others, and European ethology still others. That these systems have implications for learning radically different from those of the learning theory point of view is quite clear... and, indeed, it is the awareness of such implications and their plausibility that now cause many to argue that the older views must be jettisoned. But, as yet, only scattered and diverse propositional elements have been advanced, not a system of them to form a pretheory. One recent sketch of an assumptional system consistent with present-day data (White and Fishbein, 1972) was completed after the close of project efforts, but is a direct outgrowth of the work undertaken in it.

The peculiar salience of research on attention for the understanding of learning comes about because of the peculiar importance of the pretheoretical issues. One of the strategic weaknesses of the "learning theory point of view" was always, precisely, its theoretical blindness to issues involving attention. The term 'attention' was almost dropped from usage in American psychology after 1920, reviving only after the cognitivism of the middle 1950's began to come in. The learning theories rested their analysis on the premise that learning revolved around the observable stimulus, in the environment, manipulable and observable by the experimenter. As a consequence of this position, the traditional analyses of learning were in very short order "haunted" by irreconciliable issues reflecting the repressed issue of attention.

Highly active and elaborated theoretical controversies were developed, but the considerable literature of crucial experiments about such controversies never got anywhere because the controversies (place vs. response learning, continuity vs. noncontinuity of learning) all rested on rivalrous and unarticulated premises about the attention or orientation of the learner (Osgood, 1953). Attentional effects noted in various experiments were all relegated to etcetera analysis in the discussion sections of research papers, usually to be there explained by the invocation of some special "set" factor. Finally, there came to be appeals that the word "set" be abolished in the usage of experimental psychology, because it clearly was becoming the "wastebasket" of learning research, the place where one put everything unexplained.

One might expect, because of this history, that the consideration of attentional processes and mechanisms would go a long distance towards clarifying issues obscure in our previous understanding of learning. However, one would also have to expect that an understanding of learning resting on a consideration of attentional factors cannot be achieved in the context of the "learning theory point of view," or by any simple modification of it. We need to consider attention in relation to learning, but we will need to think about learning in rather different ways in order to do so.

All of this may seem somewhat rarefied in the context of a need to consider educational issues, very much a part of technical psychology and the rather specialized games of theory construction. But large parts of our semi-technical or everyday discourse about learning are diffusions from the technical literature. Textbooks of psychology, educational psychology, child psychology, have regularly delivered the fruits of the technical considerations in more simplified language. And, in turn, the discourse about learning in ordinary English holds to consistency with old associationistic assumptions that our work on learning only now begins to throw over. One finds, in the language still, the assumption that learning is additive, bringing increments of knowledge or behavior to the learner. One finds the assumptions of the distinctness of perception and learning on the one hand, the distinctness of motivation and learning on the other. All this has important implications for the way the teacher or the curriculum developer confronts his task. And, as well, it has significant implications for program planning and policy considerations with respect to education...what we imagine a new educational program can or should be expected to achieve, what we imagine an evaluation of an educational program should evaluate.

The project was an attempt to understand the nature of children's learning more adequately, and it pursued questions of how attention relates to children's learning in order to draw forth such understanding. Having set forth these pretheoretical aims, it seems worthwhile for a moment to consider the analysis of developmental changes in the 5-7 age range in relation to it.

There is much evidence of change in children between 5-7 years, diversified evidence that will be considered in some detail subsequently. Considering all such evidence it is still possible today to take what might be regarded as a "strong" or "weak" position with regard to the observed changes in children in this age range. The "strong" position would be that all of the evidence betokens a stage change in the development of children at this time, a second adolescence, a reorganization of the child's capabilities for thought, perception, socialization, and emotion that is so indigenously profound in the child that any society containing children would have to adjust to it. The "weak" position would be that all of the stagelike attributes of this age range are illusory or may be dismissed in one way or another. There are diversified changes in the child in the 5-7 age range, but we tend to exaggerate the importance of this time simply because the value of a search for, and comparison of, the diverse literatures of childhood change and development in this age range comes primarily because we have an unusually large and diversified body of data about the development of children at this time (in contrast, say, with our literatures on human development from 1-3 years of age, or adolescence, or middle adulthood). The strong position would hold that we have in the 5-7 period a time of pronounced change in the character of the child. Among the implications of a strong position would be, generally, the argument that this time of life might very well offer the boundary points for critical or optimal periods in

ED 009 664

development. Freud tended to advance such a view about this time, arguing that the infantile sexual stages of human development before six fix once and for all the basic personality and character of the individual. Speaking more specifically towards educational concerns, Maria Montessori earlier and Benjamin Bloom more recently have set forth arguments that are implicitly a strong view of developmental change at this time. Montessori argued that the child's thought and experience have a distinct character before five. The child thinks and knows and feels the world in ways that are lost later and so lost learning in the early years is irrevocable. Bloom's (1964) thesis that human IQ stabilizes in the early years of life is well known because it is so often referred to in discussions of Head Start. From Montessori we get one view of the meaning of preschool, from Bloom another, but from their strong positions about change in human development at this time we get the characteristically strong educational recommendation that special kinds of preschool experiences may be necessary in the development of children.

At the outset of work on this project, the approach taken to the 5-7 material was that analysis in this age range would provide a broad and proper context for the data of change in learning in this age range. Experimental studies of learning had repeatedly demonstrated suggestions of transitions or shifts in performance in this age range, but extended experimental analysis amounting to a literature of hundreds of studies had failed to gain any ground in interpreting or explaining the shifts. In particular, studies of the best-known phenomena of change at this time, change in the transposition experiment and change in the reversal shift nonreversal shift procedures, had been exhaustively pursued without conclusively settling the opposition between the two dominant theoretical conceptions offered to deal with them -- one a mediational hypothesis (Kuenne, 1946; Reese, 1962; Kendler and Kendler, 1962) and the other an attentional hypothesis (Zeaman and House, 1963). One way out of the stalemate might be through engaging in some constructive "detour" behavior. Go outside the empirical boundaries and theoretical boundaries within which the dispute had been contained; look at data other than those of the generalized discrimination learning procedures and look at hypotheses of transition other than the theoretical conceptions keyed to the discrimination learning data. From data and conceptions so arrived at one might understand more adequately how one should construe the experimental data of change in learning at this time.

The prolonged analysis undertaken during the course of this project made this entering conception of the problem less and less satisfactory. A kind of "figure-ground" relationship is implied by the approach. The changes in the experimental learning procedures are taken as primary, as "figure," and the variety of other material about the age range is taken as the basis of a context or "ground." If one juxtaposes all the variegated phenomena of change in this age range, and all the hypotheses, one gradually comes to believe that this is a kind of cart-before-the-horse approach. The experimental learning data are local, particularized, somewhat ambiguous, reports of change arising out of children's reactions in

an artificial and stylized situation. They have the advantages of being relatively precise, relatively replicable, phenomena but these are by no means unique advantages among the phenomena of change at this time. What more and more rises out as "figure" when one looks at the body of data is the very question of the meaning of the body of data as a whole. Should one take a "strong" position, or a "weak" position, or any one of several intermediary positions, about the meaning of this body of data? Children make a major entry into society at this time, coming into schooling in the developed nations, coming into a more adult status in other ways in less developed cultures. What is the basis in human development for this? There are a variety of known or suspected changes in the physiological characteristics of the child at this time. To what extent do such changes form the nexus for the variety of cognitive stage changes proposed at this time? To what extent do they clarify questions of the issue of readiness? In short, it seemed more and more reasonable as time went on to relegate the learning phenomena to the status of constituting just one of the variety of deflections, shifts, alterations that seem to exist in abundance in the variety of developmental literature at this time. At the center of consideration comes consideration of changes in the child's cognitive and social development, questions of the nature and meaning of their biological basis, questions of the nature of changing social expectations about children at this time and their influence on the observed phenomena of change.

Despite this kind of shift away from an emphasis on the technical data of learning, the most reasonable organization of the larger approach still implies a heavy emphasis on the analysis of learning...now not questions of how various odd phenomena of learning experiments occur, but instead questions of the nature and development of those abilities considered as representative of the ability to learn in the context of the school. The "readiness" implicit in the entry of children into schooling is almost surely not a matter of intellectual readiness, information-processing skills, or cognitive structuration. One of the distinctly open questions right now in developmental theory is the question of how much of the cognitive gains manifest during Piaget's period of concrete operations represent new entities distinct from and unprecedented in the cognitive abilities of the child before this time.

It appears likely that an important part of "readiness" in the 5-7 age range represents what might be called a readiness for <u>performance</u> as well as a readiness in terms of <u>competence</u>. This may be true in the formal arrangements of the psychological experiment as well as the formal arrangements of the classroom of the first grade. Readiness in terms of performance would apply some of the following factors: the ability to manifest emotional and motor restraint, the ability to understand a plan of behavior offered by others and to act on it, the ability to sustain a plan of behavior over time, the ability to understand and operate within rule and game systems, etc. Such factors seem significant in children's performance during psychological experiments (White, 1970b); they will

determine judgments as to whether the child "has" various cognitive competences. It is extremely likely that such factors are significant in the child's performance in the classroom. In the context of the classroom, such factors will often be noted as questions of the child's "motivation" or "attention span," although it is quite likely that at times they will form a significant part of judgments about the child's basic ability or intelligence.

The potential value of a broad-scale review of developmental changes in the 5-7 age range is the possibility of some clarification of the metacognitive issues surrounding the child's adequacy in school learning. It should be noted that this value holds true whether one takes a "strong" or "weak" position about the data of change in this age range, that is, whether one sees a dramatic stage change at this time or whether one views this as a nonspecial period of child development.

In summary, the following statements might best characterize the purposes of the project:

1. It was directed at an analysis of attentional processes as they influence children's learning.

2. It was most fundamentally pretheoretical, seeking to provide a reasonable basis for the understanding of children's learning to supplant the "learning theory point of view," accepting as its premise that questions of attention form one of the clearest and most significant set of issues for a more adequate view of learning.

3. Although the project dealt with basic issues and thus (on a customary but probably false dimensionalization) turned "towards" metatheoretical issues and "away from" direct questions of education per se, this kind of approach was felt to be essential in seeking a modern view of learning that would fit educational realities and educational questions about learning. That this would be productive was a matter of conviction at the outset of the project, but as the project was under way the work showed a clear and seemingly interesting movement towards educational settings and educational questions.

4. The work of the project was made up of a flexible series of studies, literature reviews, and theoretical analyses.

5. There were two central themes around which the effort was directed. One theme was the study and analysis of the influence of sustained attentional patterns during studies of children's learning. The other was the exploration of developmental changes in children between 5-7 years of age. These discrete investigations were intended to reinforce one another and to a significant extent this expectation seemed to be fulfilled during the course of the project.

Work of the Project

The fundamental orientation towards questions of attention in learning was and is given by the overarching analysis of the general field of developmental changes in the 5-7 age range. Our discussion will consider the steps taken in this body of work because the considerations involved in this analysis dictated a considerable amount of our approach towards direct research on attention in learning.

Work done prior to the project had established certain possibilities about changes in children's development in the 5-7 age range and it had also brought to the forefront certain questions about the nature and meaning of the changes. Generally, going into the project, prior research and analysis had established the following about this time of development:

(1) Experimental studies of children's learning had repeatedly shown certain qualitative changes in children's performance on so-called transposition and reversal-nonreversal shift experiments. For reasons that may or may not be peculiar to the history of stimulus-response theory, these changes had been widely regarded as significant and had led to significant research literature and theoretical arguments. One reason for this great interest was that this was a twice-replicated transition in childhood from animal-like to adult-like behavior on learning experiments. Perhaps some significant "human factor" began operation at this time. The second reason for the interest in these phenomena came because they could be interpreted as a product of a new 'mediational' use of language by children at this time. Since Pavlov, it has been traditional in stimulus-response theory to assume that the "human factor" sharply discriminating animal from human conditioning phenomena is or is closely related to language. Pavlov postulated that language constitutes a 'second signal system,' but Americans have tended to speak of the influence of language as 'mediational.' It appeared that between 5-7 years of age children shifted towards an adult-like pattern of learning and that this shift was at least correlated with new language usage that might be suspected of being mediational.

(2) However, other changes in learning experiments could be demonstrated that did not fit the language-mediation pattern. If cue variations are introduced into discrimination experiments, variations that make the nature or the locus of the cues inconstant, children are significantly interfered with at about 5 but seem not to be bothered by about 7 (Walk and Saltz, 1965; White, 1966; Brown, 1969).

(3) Furthermore, a more widespread search of the research literature concerned with this age range revealed preliminary findings of a surprisingly diverse body of change not only in learning experiments but also in experiments having to do with perception, language, reasoning, emotion, psychopathology, etc. Furthermore, fairly large-scale assumptions of what seemed to amount to a "stage" change in children's thought had been offered

by Freud, Vygotsky, and Piaget. While this body of data and theory generally confirmed the learning theorists' suspicion that something marked was happening to children at this time, there were significant bodies of data that could not be subsumed under a hypothesis about the development of mediation. Something more than, or perhaps other than, a new usage of language must be operative at this time.

(4) The pattern of the findings considered at that time suggested four kinds of changes in children's thinking. These four changes offered in White (1965) will be discussed below, in the context of a revised discussion of the basic cognitive changes at that time.

(5) It was suggested that the transitional findings in the 5-7 age range betokened the existence of two coexisting levels of thought in human adults,[1] a first "associative" level and a second "cognitive" level. It was argued that the first level might be dominant in determining the learning and thought patterns of the young child until about five years of age. Between five and seven years of age, this first level would tend to be inhibited, and a second level would tend to supercede it.

(6) These two levels of thought in the adult might be expected to coexist in a "temporally stacked" arrangement, marked by differences in time to access and complexity of analysis. Such an arrangement might be the basis of regression phenomena occurring with disturbances of thought. It might also form a developmental basis for the "microgenetic" patterns of response determination suggested in the literature of human thinking (Werner, 1957; Flavell and Draguns, 1957).

The set of suppositions just described were derived from a preliminary and limited analysis of the research material available. It seemed abundantly clear that psychological research to date has explicitly, in the writings of major theorists, and implicitly, in the existing patterns of research data, suggested a rather rich period of developmental change in the 5-7 age range. The project sought to pursue certain major questions requiring amplification and clarification.

---

[1] The use of the terms 'associative' versus 'cognitive' to designate the two coexisting levels of human thought was unfortunate, even though the same terminology has made sense to others in the literature (e.g., Jensen (1969). The terminology implies that associationistic principles explain the young child's thought and learning and it further implies that the young child does not think or reason. It seems terminologically much better to distinguish the two levels as a 'juvenile logic' versus an 'adult logic' or perhaps to revive Freud's distinction between "primary process" thinking versus secondary process thinking.

Analysis of Piagetian Data

One task, fairly straightforward but not quite a mechanical task, came through the need for a full analysis of the research and theory about this period presented in Piaget's work. At the time of the inception of the project, Piaget had clearly "crossed the water" and his work was receiving attention and discussion in this country. But there had not been a thoroughgoing review of the diversified Piagetian explorations of the child's entry into concrete operations. Flavell's (1963) review was then, and is now, the most detailed summary of Piaget's writings available in English. We undertook a detailed examination of the particularized evidences of change discussed in Piaget's writings (Thompson, 1966, Appendix A).

Schooling as an Artifact. It seemed necessary to explore a technical question frequently raised about the meaning of the data available on the 5-7 transitions. Do such data reflect changes in children or in their milieu? All of the research-producing societies contributing knowledge about children in the 5-7 age range (generally, the U.S., England, France, Switzerland, Germany, the U.S.S.R.) are developed societies that institute universal schooling in the 5-7 age range. To what extent do widely distributed data of change in children represent the existence of a widely distributed artifact? To what extent are we simply analyzing the influence of schools on children's thinking when we discover psychological changes in the 5-7 age range?

Maturational Determinants of 5-7 Changes. If one could believe that the changes at this time were not totally produced by schooling -- that is, that data existed that could not plausibly be considered an effect of schooling -- then a further possibility would have to be explored. It is possible that the data delineate the developmental basis of 'readiness' for schooling and that they may be helpful in constructing an understanding of the factors in child development that are favorable for schooling. Since it has been argued that school readiness depends, among other things, upon sufficient maturation of the child's nervous system, questions about such maturation become of considerable interest for the analysis.

Social Determinants of 5-7 Changes. Children change their status in society in the 5-7 age range. The most conspicuous sign of this is the fact that they are expected to enter school at this time, but there are other changes as well. These social changes may or may not represent a historical reaction to the readiness or eligibility of children for society, but they represent a new environmental force in child development. One is led to ask in more detail what the changed expectations about children are in this age range, what new sanctions, what new rules, what new ecologies of society are placed before them? What is the nature of the "social stage" erected by society at this time?

Cognitive Changes in the 5-7 Age Range. Although our preliminary analyses had yielded considerable information about cognitive change at this time, we were hardly satisfied with the data available or the formulations first offered to try to fit them. It seemed necessary to try to obtain further data about cognitive change at this time for several reasons: (a) to attempt simple replications of some of the reported findings; (b) to try to establish empirically the coincidence or non-coincidence of changes offered in discrete sources; and (c) to try to explore what seemed to be some significant methodological issues suggesting themselves as applicable to a large amount of the data. The value of (a) and (b) seems self-evident. The issue under (c) was and is the question of the child's growing cooperativeness with experiments, which seems to offer significant problems for interpretation of much of the existing data. Therefore, a significant part of our efforts lay in trying to explore the issues of basic cognitive change in more depth.

In summary, project work on the material of the 5-7 year age range in children was intended to build on the basis of the previous analyses (White, 1965, 1966) to answer certain questions that could be put to the original analysis and to explore the issues further. The project sought to examine Piaget's work more closely and carefully. It sought to consider the influence of schooling on the data of transition and the possibility of an influence of the transition on schooling itself. It sought to consider maturational and social forces as they might create the developmental change. And finally, it sought through experimental analyses to explore the cognitive changes in more detail.

Survey of Piaget's Findings. At the beginning of the project, we recognized that the single largest coherent body of data about children in this age range was that body of data represented in Piaget's writings. Flavell's (1963) summary of Piaget, then and now the largest digest of his Piaget's writings available, spends most effort outlining the rather complex theoretical structure developed in Piaget's writings and relatively little time detailing the mass of particular findings. Piaget's theoretical analysis of the development of cognitive structure is, in fact, the most fully adequate analysis of an important set of findings of cognitive change in this age range. We were concerned to try to find the full size and shape of the body of findings presented in Piaget's writings and, accordingly, a content analysis of Piaget's writings was undertaken. We undertook to go through the body of Piaget's work available in English translation in 1966 -- The language and thought of the child, Judgment and reasoning in the child, The child's conception of the world, The child's conception of physical causality, The moral judgment of the child, The construction of reality in the child, The psychology of intelligence, The child's conception of space, The child's conception of geometry, The growth of logical thinking from childhood to adolescence, and Logic and psychology. With the exception of one of Piaget's monographs concerned with infancy (The origins of intelligence in children), we covered the then-available English writings of Piaget in an attempt to summarize his theoretical assertions and his empirical observations bearing on the onset of concrete operations in children at seven years of age.

The result of this summary is given in Thompson (1966), included in Appendix A. This summary is still a reasonable guide to the empirical material contained in the Piaget monographs that were covered but, for a variety of reasons, it is not fully adequate today. To begin with, there has been considerable new empirical material available in English because of the growth of his popularity in this country in recent years. Generally, the later empirical material is more completely and fully documented. But the survey of Piaget has not seemed adequate because of its coverage of the Piagetian theoretical structure. A diagrammatic picture of the Piagetian theoretical analysis is given in Part I of Thompson (1966). It was developed from Piaget's writings, but it is largely a rendering of the earliest and simplest phase in the development of Piaget's theory. There was an early phase in Piaget's work when his approach was quasi-psychoanalytic and when it was largely an analysis of the symptomatology of the young child's thought. The diagram pictures Piaget's view of the trend into concrete operations at that time in his theorizing. From the point when Piaget crystallized this view of the process of development until today, he has been concerned with a progressive translation of this clinical description into a model of growing cognitive structure. In addition, he has centered his theory more and more within the issues of genetic epistemology.

Despite the circumscriptions of the literature analysis, it proved useful in pragmatic and thematic ways:

(1) It provided a digest of specific Piagetian findings bearing on the development of concrete operations. This has been useful and continues to be useful.

(2) It developed the Piagetian theme of a 'socialization' of thought. According to Piaget's analysis, the various 'symptoms' of preoperational thought disappear because of the pressure of the child's conversations with others and the consequent need to explain and justify himself. This is an explanation that calls for further explanations...

> "What pushes logical development is the felt need to go beyond the self, consider and integrate other points of view, and represent reality to the self independent of present actions. The child is only motivated to do this in order to be able to communicate."
>
> (Piaget, 1954, pp. 366-367)

why should the child, who has been talking to others since he was two, suddenly show this new sensitivity to communication only at seven? Nevertheless, incomplete though this explanation may be, it is provocative in its resemblance to other explanations of other phenomena at this time. Freudian theory, through positing an "internalization" of parental sanctions, argues that the superego formation characteristic of this age range

is a taking of the role of the other. Various cultural institutions associated with this age range (White, 1968) seem to be based on a heightened sensitivity of the child to dominant ethical and religious assumptions of the culture.

(3) It brought forth repeated evidence in Piaget's writing of what appeared to be the extension of a temporal factor in thought. A great many of the Piagetian experimental demonstrations of change in thought at this age range seem to have to do with the problem of consistency of thought over time. At the younger age range, something the child sees or does earlier is not consistent with what he sees or does later...the child is not concerned about such consistency. For example, in the by-now famous conversation experiments involving volumes of water, solution of the problem is impossible unless there is some kind of summation or integration of thought over time. The key question of this experiment.... "Is there the same to drink in each glass"....is asked of the child while he confronts a short, fat glass with water at a lower level and a tall, thin glass with water at a higher level. No child can answer that question if he simply considers the scene before him. No adult can (unless he makes some rather sophisticated measurements and calculations). The adult answers the question easily, and the child may or may not answer the question, depending upon whether he considers the present scene in conjunction with some scenes in recent history...the two short fat glasses seen to be equal, the contents of one of the two short fat glasses being poured completely into the tall, thin glass.

Many of the Piagetian experiments can be seen in this way. Events or information or actions made earlier in time have to be brought forward in time so that they have an effect on a critical judgment or action of the time. We became interested in this, particularly because a variety of non-Piagetian experimental findings looked like they could be made to fit the principle.

Traditionally, the question of the "attention span" of children has to do with a grosser definition of the integration of behavior over time. The child is observed in the initiation of an activity -- solving a problem, playing with some specific materials, socializing with another child -- and the observer counts the time until the child breaks with the activity and enters into another. There is, on the average, a lengthening of activity time measured this way as preschool children get older. Our working hypothesis has been that the factor or factors that promote the gross kind of attention span in children are the same as those that promote the special kinds of cross-time integrations required for the Piagetian demonstrations. An important part of the experimental work undertaken in the project has to do with the study of the factors in "attention span."

Changes Between 5-7 years and the Onset of Schooling. In work to be described below, further efforts were made to explore the "socialization" and "time spanning" interpretations of change in the 5-7 age range. But

there were, and are still, important questions about the general findings of change in this age range. It has been our consistent belief that where there is so much smoke there must be fire. Where there have been so many and diverse reports of significant developmental change in the child occurring at this age range, something significant...some "stage" change, perhaps...must be occurring in the child. However, the great majority of the data do not have to be a consequence of some intrinsic developmental changes in the child. All data-producing societies -- the United States, Britain, France, Germany, Russia -- regularly put their children into public schooling between five and seven years of age. It is likely that some of the available data of change, and it is conceivable that all of the data, are produced simply by the effects of schooling on children -- that is, essentially as an artifact of something other than the development of the child.

Since it was our hope that these data might be the basis of an analysis of the preconditions of schooling, it seemed important to directly address this issue. Accordingly, some specific kinds of literature were sought out to address this question. The basic question was whether or not there is some major intrinsic change in the child's growth pattern, something like adolescence, that was clearly not a reflection of the impact of schooling upon him and that might conceivably delineate a developmental basis for school "readiness." Three kinds of literature seemed to bear upon this question:

(1) We can ask if there are physical changes in the child between 5-7 years not plausibly a consequence of schooling but plausibly linked to the psychological changes at this time.

(2) We can ask if there is some cross-cultural universality of practices or beliefs that appear to acknowledge significant change in the child at this time.

(3) We can ask if the experimental data obtained in societies where children are put into school can be replicated in other societies in which children of the same age are not put into school.

A review of evidence bearing on these three questions was developed in White (1968). Subsequently, further evidence bearing on the third question was obtained by Super in a cross-cultural study to be discussed subsequently. The 1968 review of data suggested the following:

(1) There has been some repetition of evidence suggesting a "mid-growth spurt" in children's physical growth, this shift occurring between 5-7 years. The spurt has appeared in grouped anthropometric growth data. It appears to be more characteristic of weight and width body measures rather than length measurements.

(2) There are heterogeneous, isolated data suggesting shifts in endocrine function and shifts in rate of neural tissue growth at this time.

(3) There is a small, heterogeneous body of data all suggestive of a "hardening" of the child's mental or neurological status around age six. The data bear on (a) the traumatic effects of hospitalization, (b) the effect of diabetes on subsequent IQ, (c) the optimum age of dietary treatment of phenylketonuria, (d) the incidence of febrile convulsions, and (e) the period of florid symptomatology in childhood autism. Each line of evidence finds a change in the vulnerability of the child, or his accessibility to treatment, at around six years of age.

(4) In our own cultural history, traditions apart from schooling reflect assumptions that children are partially mature at 7. In the Middle Ages, according to Aries (1962), there was a general presumption of maturity at this time:

> "Once he had passed the age of five or seven, the child was immediately absorbed into the world of adults...."
>
> (Aries, 1962, p. 329)

> "In the Middle Ages, at the beginning of modern times, and for a long time after that in the lower classes, children were mixed with adults as soon as they were considered capable of doing without their mothers or nannies, not long after a tardy weaning (in other words, at about the age of seven). They immediately went straight into the great community of men, sharing in the work and play of their companions, old and young alike."
>
> (Aries, 1962, p. 411)

It is quite possible that these medieval traditions have been carried down through the years to an embodiment in two traditions of our own time. The English Common Law assumes that a child is first capable of being guilty of a crime, first aware of right and wrong, at the age of seven. The Catholic Canon Law assumes that a child has his first knowledge of sin at age seven and can first validly confess from that age, and hence places First Communion at age seven.

This 1968 review of evidence is included in Appendix A. It appeared from the review of evidence that there was some basis for the belief in some substrate processes of change in the child independent of the influence of entry into schooling upon him and, quite possibly, indicating some basis for what is generally called "readiness" for schooling. That such evidence can be obtained does not, of course, validate any and all evidence of change in the general literature as evidence of basic change in the child. There is good reason to believe that schools cause changes in children which are sometimes interpreted as developmental changes in

the research literature. But the 1968 review suggested that it was reasonable to believe in a contributory maturational process, although it gave no indication of what that process is. To date, even with further efforts to be described below, we have no clear idea of what the neuropsychological substrate might be. But the possible existence of such a substrate seems to be a clear issue for later research. In a following section, below, we will offer some summary comments on "readiness" for schooling.

This paper represented our first attempt at an analysis of the literatures of a number of disciplines other than Psychology -- anthropometry, neurophysiology, various medical specialties, cultural anthropology -- and we felt that the work was necessarily tentative. Subsequent examinations of the literatures of these disciplines have moderated the judgments embodied in that paper although they have not discounted the general conclusion of the paper. If anything, they have strengthened it. But we would now be inclined to modify the arguments in that paper according to the following considerations:

First, the anthropometric evidence for a mid-growth shift in the 5-7 age range seems tenuous. Correspondence with James Tanner and Howard Meredith revealed their own uncertainty about the genuineness of such a phenomenon. In Tanner's (1970) authoritative review of physical growth patterns in children, the notion of a mid-growth spurt is not brought into discussion at all. The phenomenon has been decisively discounted. However, there is a possibility that the phenomenon arose as an artifactual property of grouped growth curves. At present, there is an ongoing analysis of the patterns of individual growth curves being conducted by Dr. Rose Fritsch at the Harvard Growth Study. But we have not been able to undertake an independent analysis of her data to examine whether they support or deny the notion of a mid-growth spurt phenomenon.

Second, the assorted medical evidence discussed in the paper for an indication of a mental or neurological "hardening" of the child's status at age six could probably be extended. In the clinical literature on amblyopia, there is widespread testimony to the effect that the disorder of vision can only be improved to the extent that treatment is given before six years of age. There is no generally accepted theory about the physiological basis for amblyopia. Rather, there are a group of theories emphasizing various peripheral or central mechanisms. There is some agreement to the effect that the oculomotor are "grounded" or stabilized at about six years of age. In the clinical literature on deafness, there is the belief that spoken language can only be established in the deaf child if speech training is established before six years of age.

Third, the cross-cultural literature on children's cognitive development has grown since 1968 and suggests conclusions different from those possible at that time. In 1968, there were only the beginnings of what has now become a large-scale effort at cross-cultural studies of cognitive development. Piaget's stage theory precipitated an enlarging body of effort to establish the cultural universality of his developmental scheme,

with particular interest in the onset of concrete operational thinking at around age seven. The few findings available in 1968 suggested that concrete operational thought emerged relatively independently of the child's cultural milieu. Subsequent findings have qualified this conclusion and have suggested a more complex, more culturally contingent, pattern of emergence. These findings are reviewed in Super's (1971) report, included in Appendix A.

Summary Themes: A reanalysis. In a first survey of the psychological literature on change in the 5-7 age range, an initial set of summary themes was proposed. At that time, the various data of transition were taken to be reflected in learning by a shift from 'associative' to 'cognitive' processes of engaging in learning. Subsequent analysis of the psychological literature made it more and more necessary to review the overall pattern of the psychological findings -- first, because rather different summary themes suggested themselves and, second, because the analysis of the literature made it less and less likely that what was happening to children's learning could be reasonably described by terms like 'associative' or 'cognitive' function.

The proposing of summary factors is a speculative process which, we believe, is necessary and useful. If one collects together assorted research findings indicating change in the child between five and seven years, one does so in the belief that the various findings when taken together will suggest underlying functional changes in the child which are not so clear if only limited sets of findings are examined. However, given a large set of heterogeneous research findings, there is no orderly, highly reliable procedure for asserting one best system of simple determinants. Undoubtedly, various investigators looking at the body of findings will come forth with various sets of such determinants. One can, to some extent, attempt to make the various phenomena of transition in the child reveal their unities by an empirical method. One can take sets of procedures which, in various laboratories, have revealed changes in the child and one can administer these sets to a group of children. This might reveal clustering of observed transitions. We have attempted this kind of empirical examination in a series of studies to be outlined below. However, the advantages given by the objectivity of the approach is seriously compromised by the disadvantages occurring through practical and methodological difficulties. Consequently, it has seemed more important to try to search for integrative determinants among the data by rational and judgmental processes. Determinants so arrived at are, fundamentally, hypotheses about the observed transitional phenomena and serve as a source for subsequent research efforts designed to confirm and elaborate the hypotheses. In this project, the separate research studies to be described below were guided in part by our judgments about summary themes in this age range.

In an earlier analysis of transitions in this age range, the following arguments were set forth:

1. There exists in older children and adults two different modes of cognitive function -- termed 'associative' and 'cognitive.'

2. These modes are "temporally stacked." They are differentially available in time. When the stimulus initiates the hunt for a response, the first-available mode is the associative mode. The later-available mode is the cognitive mode.

3. Inhibition of responses determined by the associative mode is required in order that the cognitive mode determine the activity of the subject. Factors influencing the ability of the subject to form or maintain inhibition therefore influence which mode of thought will be expressed in his behavior.

4. Between the ages of five and seven years of age, there is an important establishment or augmentation of cognitive function, so that it becomes a dominant system of thought. The child before five predominantly expresses associative function, either because important components of cognitive function do not exist or because he is not able to impose a necessary kind of inhibition.

5. Various kinds of psychopathology traditionally presumed to cause regression may do so because they have a disinhibitory effect upon the subject's thought. The subject "regresses," not back to the exact thought and behavior of a child, but to a level of associative function which is itself developed and extended and become mature.

6. Cognitive function, as opposed to associative function, is an expression of the following summary themes:

(1) The use of language representations of stimuli as "pure stimulus acts," as second-order cues evoking behavior which the stimuli themselves would not call forth.

(2) The ability to maintain orientation toward invariant dimensions of stimuli in a surround of variance.

(3) The ability to string together internal representations of stimulis-response-consequence into sequences which, projected into the future, allow planning and, projected into the past, allow inference.

(4) Relatively more sensitivity to distance receptors of vision and audition and relatively less sensitivity to near receptors of emotion, touch, pain, proprioception, and kinesthesis (White, 1965).

The augmentation of this literature analysis made possible by the project provided, finally, a reconsideration of the above analysis of the functional terms of the change. A subsequent paper (White, 1970) offers a further analysis of the phenomena of change in this age range and a

revised set of summary themes. This paper is given in Appendix A. This paper addressed itself to contrasting modes of thought which are called a "juvenile logic" and an "adult logic," and the adult logic is said to be distinguished from the juvenile logic by the following:

(1) A sharply enhanced ability to form a system of behavior in accord with a proposition offered to the child and, then, an ability to maintain the proposition over an extended period of time.

(2) An increase in inhibitory mechanisms manifesting itself in diverse ways.

(3) An increase in the access of certain kinds of memory or awareness to verbal or voluntary processes.

(4) The ability to superpose dimensionalization on the concrete situation, so that the child does not so much deal with events as with events-in-context.

(5) A relative decline in what might be regarded as affective dependence upon other humans and, together with that, the ascension of what might be called contractual dependence.[1]

---

[1] In this summary statement here, the word 'contractual' is asserted in place of the original word 'competitive' (White, 1970b). A reinterpretation of the issue is involved, one which appears to make it more general and more useful. The original assertion of the development of competitive dependence was based on several lines of evidence that seemed to converge. There has been a large body of research on dependency in children over the last several decades, and a consensus among dependency researchers suggests that a more juvenile form of children's dependency should be distinguished from a different, more mature, expression. The younger manifestation seems to lead to a need for contact with adults and comfort from them; the more mature manifestation seems to depend upon more symbolic expressions of approval by others. See, for example, the distinction between "near receptor" versus "distance receptor" forms of dependency discussed by Walters and Parke (1965).

The emergence of the more mature kind of dependency seems to coincide in time with personality characteristics called 'genuine competitiveness,' 'need achievement,' or 'ego involvement in task success' (White, 1970b). Some unpublished research by Dr. Daniel Freedman of the University of Chicago seems in line with this trend. He has conducted observational studies of the social behavior of children ages 4 and older and he has observed, beginning at ages 5 and 6, that male children begin to establish stable cliques in the school setting, groups that move around together in the environment. He also finds, at this time, the emergence of a "dominance" principle within these cliques. The children have some mutual, stable agreements about who is best at various activities. (If two four-year-old boys are asked who is the best fighter, they are both apt to

(footnote continued)

answer, "I am." If two six-year-old boys are asked the same question, they will both tend to agree that one or the other is.)

The original assertion of the emergence of a principle of 'competitive dependence' between ages five and seven was based on the idea that both the age changes in dependency and the age changes in competitiveness were different facets of the same transition. However, a recent series of cross-cultural studies by Dr. Millard Madsen of UCLA (Madsen, 1967; Nelson and Madsen, 1969; Shapira and Madsen, 1969; Madsen and Shapira, 1970; Kagan and Madsen, 1970a, 1970b; Madsen, 1970), has suggested a wider view of the transition. He has developed some ingenious two-person games which children may approach using either cooperative or competitive styles of play. His research has shown significant cross-cultural differences among children with, for example, Mexican children much more apt to engage in the games cooperatively than American children. He finds these cultural differences emergent at six or seven years of age. Taking into account Madsen's findings -- and other findings suggesting that American children are more socialized toward competition than are other children (e.g., Bronfenbrenner, 1971) -- a broader principle of the emergence of 'contractual dependence' may hold for this age range.

The general idea would be that there is a social development parallel to the cognitive developments studied in this age range. Piaget's theory holds that in this age range, the child applies stable dimensions to his conception of the objective, physical world. He recognizes space, time, location, volume, etc., as stable coordinates of the world and of objects within it and he operates on his experience in terms of operations involving these coordinate systems. The parallel argument would be that this kind of dimensionalization or 'theorization' applies to the child's social experience as well. There is a widespread belief that the child should begin to "know the rules" in this culture and in others (White, 1968). What may be most generally true in this age range is that the child enters into a new level of social interdependency with others, one which is governed by the characteristic 'social contract' envisaged by the mores, courtesy, normative myths, style, and laws of the culture. He may, in this culture, enter into a 'competitive dependency' with others, governed by rules that call for a full, wide open, and fair competition. He may, in other cultures, enter into a different system that calls for a 'co-operative dependency.'

Kohlberg's (1969) theory of moral development sees children's socialization as mediated by a cross-culturally universal development of the notion of reciprocity, or fairness, between individuals. It is here argued that the various cultural usages of this development are tied in with different qualitative schemes for social arrangements among individuals, different rules and roles of the social game.

(6) An increase in speed of reaction and speed of recognition. What we have arrived at in this analysis is by no means a theory or a model of change at this time. Like all theoretical statements about the transitions in this age range, it is, in fact, really an attempt at more careful and analytical descriptions of the phenomena of change at this time. These rubrics are attempts at such careful descriptions of what the basic observed changes may amount to. They take into account the fact that children in this age range are significantly more able to deal with formal systems, rules, and games offered to them by adults. That is, there is a marked increase in the ability of the child to 'cooperate' with the systematic routines contained in experiments, in school classrooms, and in certain rule systems in the larger community. The rubrics are to a significant extent an attempt to locate the precise acquisitions involved in such 'cooperation.'

Studies of the Coincidence of Changes in Children

A series of studies of behavior changes in the 5-7 year age range was undertaken using nursery and public school children in Brookline, Massachusetts. There were three purposes guiding such studies:

First, the existing literature on developmental changes was characterized more by breadth than depth of investigation. Although a significant number of changes in behavior had been reported in previous work, the majority of such changes had been reported once and were unreplicated. In the several cases in which there was a literature of replication and follow-up, it was usually the case that succeeding studies had modified... or, in a few cases, denied...the original interpretation offered to an observed change.

Second, there seemed to be a need to look at the coincidence of change in the same children. While a good number of transitions in this age range have been conceptually fitted together under the Piagetian or other theoretical schemes, there does not exist much research literature in which the empirical co-occurrence of change has been investigated.

Third, it was at the beginning our intention to move into a longitudinal investigation after two or three preparatory years. If one wants to study how a group of changes tends to cluster or stage in the course of a child's development, then a longitudinal study of such changes seems like the most straightforward and logical way of estimation. However, conversations with several investigators who have had experience with longitudinal studies led us to delay the gathering of a longitudinal sample. Longitudinal studies are extremely time-consuming and they move at a demanding pace. If the procedures used in such studies are not satisfactorily developed, there is little time to experiment with them or modify them. We felt that some cross-sectional studies would give us experience in administration of a body of procedures that might then be used as the basis of a more definitive longitudinal inquiry.

So a series of studies of nursery and early school grade children were undertaken. In these studies, the same child was given a battery of procedures during one, two, or three sessions coming close together in time. There were necessarily limitations in this way of trying to collect the phenomena together. One could only group together certain kinds of changes for investigation in this manner. Some of the observed 5-7 transitions are not observable in experimental contexts or are not experimentally manipulable. Furthermore, if a set of procedures is to be massed into a battery for use with children ranging down to the preschool age range, each procedure must necessarily be fairly brief in administration. Finally, procedures given seriatim in time can and do have an influence upon one another, and so some care had to be exercised in constructing the battery to try to avoid idiosyncratic influences of one procedure in a battery upon the results obtained in other members.

A series of cross-sectional investigations were undertaken using children ranging in grade from nursery school through to the third grade. School-aged children were taken from classrooms considered "average" in the Brookline school system. Brookline, Mass. is a suburb of Boston that was once rather wealthy and fashionable, but now holds areas that range from lower- to upper-middle-class socioeconomically. No attempt was made to estimate the SES of children used in these studies, because this was not felt to be an issue relevant to their purposes. The choice of "average" children was a straightforward attempt to avoid classrooms considered to be made up of relatively bright or dull children. Children were white, of both sexes. The nursery schools used were selected so as to "connect" with the schools used. That is, the children from our nursery schools conventionally entered into the primary school classrooms from which we selected. As is usually the case, however, our nursery school children probably represented a limited and somewhat biased proportion of our school population. We did not attempt sampling corrections to try to remove this bias, because of several considerations. First, some experience with studies crossing from nursery to school groups led us to hope that these biases were not a seriously disturbing factor. Second, we were not optimistic that straightforward matching procedures -- e.g., matching children on income or education of parents -- would remove the biases. There are a number of considerations involved in whether a child is sent to nursery school and which nursery school is selected for him: educational philosophy, convenience, popularity, style. If the selective appeal of these factors to different parents biases the samples of children collected at various nursery schools, it seems almost impossible to develop an orderly procedure to "take out" these biases. Third, a significant part of what we were trying to do was to repeat findings established in studies in which unselected nursery and school populations had been used. It seemed justifiable to follow the practices of the studies to which we were trying to relate.

Each child was tested individually in a special room assigned to us for individual testing. Using successive samples of children, we experimented with variations in amount of testing, instruction, procedures

included. Our goal was to try to develop a battery of testing procedures which seemed comfortable in length, particularly to the preschool children, and for which the instructions seemed clear to the children. This battery was to incorporate procedures which, in the previous literature, had yielded developmental transitions in the 5-7 age range. One or two of the procedures were included not because they yielded marked qualitative changes or shifts in behavior at this time, but because some special significance was attributed to their more gradual change at this time. This was true for the tests of digit span memory, to be discussed below.

Several hundred children were involved in consecutive cross-sectional studies in this series. We emerged, finally, with a testing procedure employing 13 procedures that seemed to fit satisfactorily together. These procedures,and the reasons for their use, will be briefly described in the sections that follow.

Digit Span. Testing was undertaken to establish a forward digit-span, using the standard one-per-second digit presenting procedures of the Wechsler series of tests. Children do not show any marked shift in digit-span recall in the 5-7 age range, but there were two nevertheless reasons for including a test for digit span in the battery. First, the digit-span test has shown a peculiar salience as an index of general mental ability during the preschool years. Scores on digit-span are the best single subtest predictor of Stanford-Binet IQ until about six years of age, after which vocabulary takes over (Teeman and Merrill, 1962). This could reflect the peculiar construction of the Stanford-Binet test, which tends to be a "performance" test in the preschool years and a "verbal" test in the school years. If this is so, it is interesting that digit-span should be a predictor of the "performance" period of the test and not immediately obvious why this is so. A second reason for including the digit-span had to do with the relevance of digit-span estimates for an important emergent hypothesis about the general course of children's cognitive development during the school years. Several have recently argued that the general course of cognitive development in childhood is strongly related to a speeding-up of mental functioning in the course of cognitive growth. As the child becomes older, he recognizes and draws forth associations more quickly and so can consider more aspects of a situation together. Piaget, in his first summary theoretical statement, The Psychology of Intelligence, discusses the child's emergence into concrete operations in this way and likens the developmental process to the gradual speeding up of a slow motion film. The relationship between speed and power of thought is discussed in White (1970). McLaughlin (1962), in a significant article, likens the successive Piagetian stages to increments in the number of "bits" the child can process. His argument holds that tests of digit-span should offer a strategic index of the information-handling capacity of the child.

Representative data obtained on the development of digit-span recall are given in Figure 1. This figure gives data from the last Brookline sample. This sample will be the basis for the series of figures to be given in this section. It represents data obtained via the last and best-developed procedure of the cross-sectional series, and it is this procedure

that was used in the African and Weston "transition class" studies to be discussed below. The filled dots of Figure 1 give data points for Brookline nursery, first, and third grade samples. N's per data point vary in this and the later figures. Twenty-four children at each grade level constituted the sample, but not all children gave usable data for all procedures and so data point N's range from 20 to 24. The children were tested relatively late in the school year and the average ages of the N, 1, and 3 children were, respectively, 4.9, 6.8, and 9.0 years.

The triangular data points on Figure 1, and corresponding data points to be found on the later figures, represent data from the Weston study of transition classes to be discussed below.

Color-Form Dominance. One of the oldest demonstrations of a transition in children's behavior during the 5-7 age range has been with respect to a phenomenon of color versus form dominance. Children are shown a two-dimensional shape -- say, a yellow triangle -- and are then asked to judge which of two other specimens are most like it -- say, a yellow circle versus a green triangle. Children before six tend to choose the object of like color, or in some studies to choose equally between like form and like color, but in almost all studies children after six show a tendency to base their choices on similarity of form. The literature on this kind of transition goes back to a French study by Descoudres in 1914 and from that time to this there have been from 50 to 100 studies of the phenomenon. Most, but not all, of the studies confirm the existence of a shift towards "form dominance." While there has been no proof of any of the several hypotheses about what this transition means, the pattern of the findings tends to suggest what may be involved. The transition probably does not reflect basic changes in the perceptual abilities of children at this time. It may reflect an increasing tendency of the child to name stimulus figures such as those used, because our names tend to categorize the figures by form. It may reflect an increasing tendency of the child to understand normative conventions applying in the testing procedure. The child as he grows older is likely to come to know that the adult's sense of the likeness of things to one another rests more on their shape than their color, and thus he may tend to read off the question about "likeness" more and more as "likeness-in-form." Going along either with the linguistic or the conventionalization explanations is the fact that the color-form shift tends to be accelerated or decelerated by intelligence, education, SES and handicap. The more favorable the child's experience has been, the more likely the transition will be found relatively earlier.

Figure 2 shows data obtained in the population described for Figure 1. Our data are in agreement with all the preceding studies in showing a relative increase in form dominance in the N - 3rd grade range, in agreement with some but not all in showing an absolute decrease in color choices in this range. The great majority of the previous studies have found a pattern of color-dominance or mixed-dominance in their nursery school age. We find a form-dominance. Generally, this kind of finding goes against a "strong" interpretation of the 5-7 changes, as discussed above, and towards a "weak" interpretation.

Figure 1

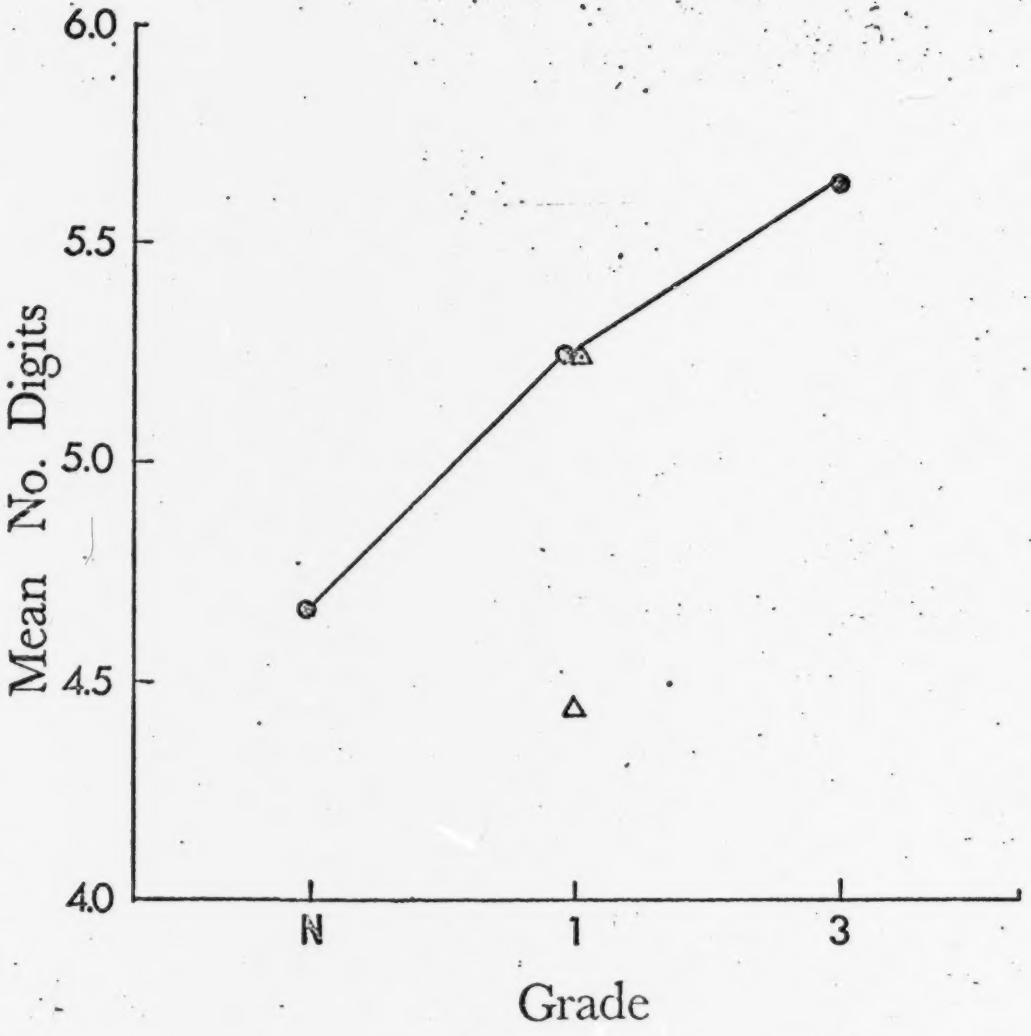
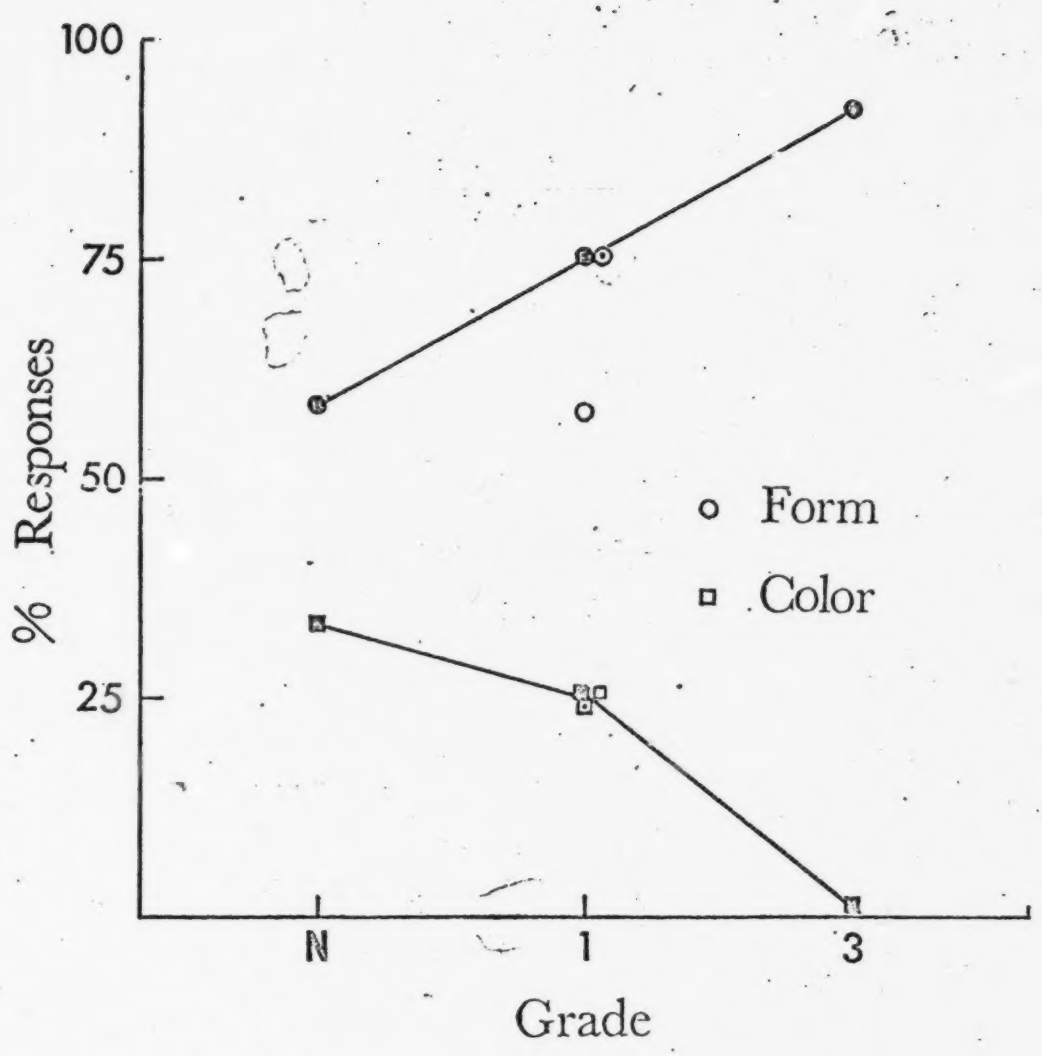


Figure 2



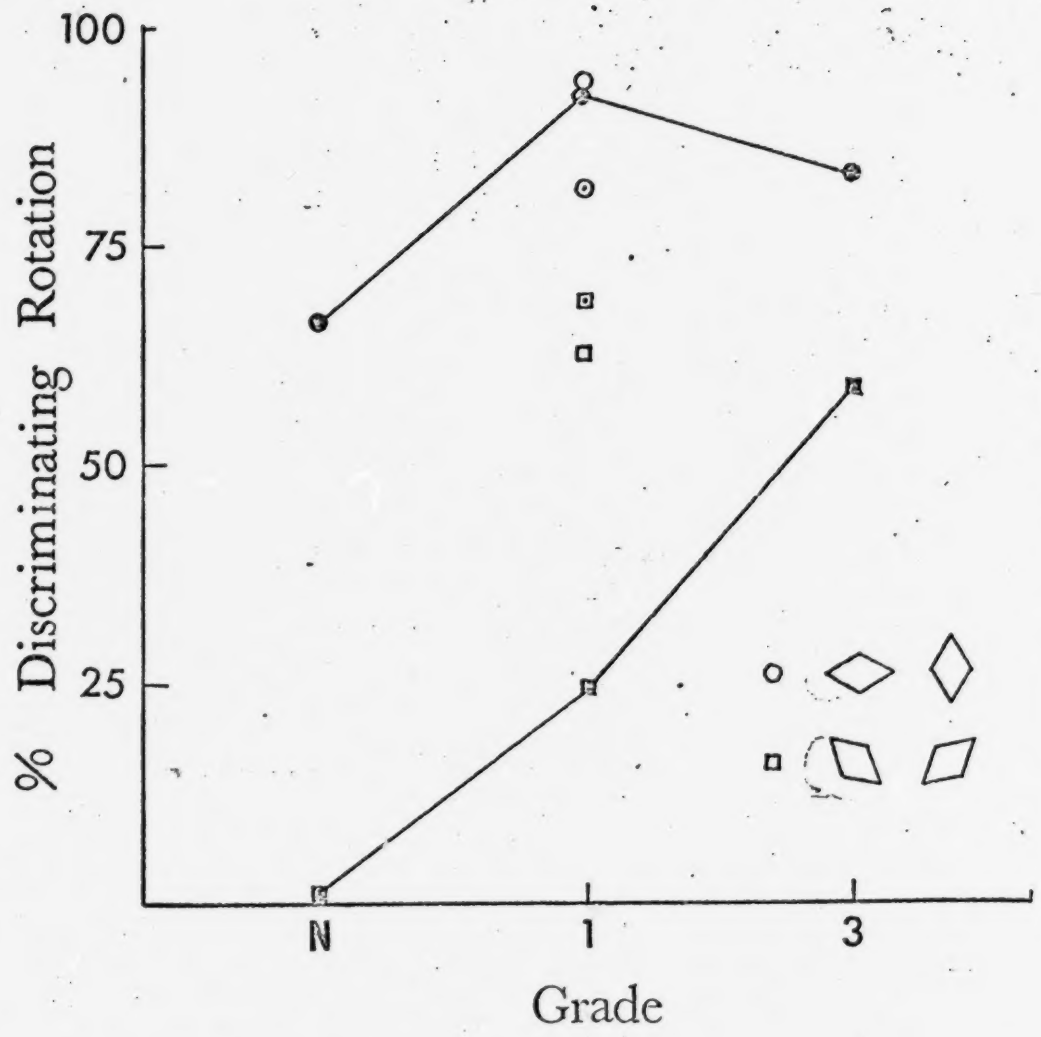
Discrimination of Rotation. It is frequently noted anecdotally that preschool children seem insensitive to the orientation of figures. Given a picture to look at, they will often discuss it while it lies upside down in front of them. They do not turn the picture around as adults do and they do not seem bothered at having to deal with the picture in an unnatural orientation. More systematic evidence, collected since the 1930's (White, 1965) has consistently shown that young children have difficulty discriminating pairs of plane figures that are mirror images. They become capable of discriminating up-down mirror images somewhat earlier and right-left mirror images somewhat later. There are some reasons for believing that this kind of orientation discrimination depends upon a base of developing neurological "readiness," but also that such discrimination may be advanced or retarded depending upon whether the child is trained to notice and deal with orientation.

One reason for believing in the existence of a neurological basis is that orientation discrimination does not develop in all U.S. children. Some children of all social classes persist in their inability to make such discrimination into the school years, despite sometimes strenuous efforts to encourage or train them. Inability to discriminate orientation is a conspicuous feature of dyslexia and at least some forms of dyslexia have long been suspected of having a neurological basis. Increasing the likelihood of neurological involvement is the fact that a frequent and diagnostic feature of adult aphasia is the loss of orientation discrimination, particularly right-left confusion. However, at the same time, one cannot believe that orientation discrimination is purely a neurological affair since there is evidence to suggest that children in general come to discriminate orientation more readily when the culture makes an issue of it.

Our test for the discrimination of orientation involved giving children a vertically oriented diamond as a standard together with a sheet of 35 comparison figures. The comparison sheet contained ten diamond shapes distributed among 25 circles, hexagons, or squares. Half the diamonds were oriented vertically, like the standard, and half were oriented horizontally, appearing to adults fairly conspicuously as the standard laid over on its side. The child was asked to check off on the sheet all the figures that were exactly like the standard. This sheet was designed to reflect sensitivity to vertical-horizontal rotation. A second sheet was given designed to reflect sensitivity to oblique rotation. The standard here was a diamond whose long axis was tilted from upper left to lower right, while the confusion figures were tilted so that their long axis went from upper right to lower left. The figures are sketched on Figure 3 to follow.

Figure 3 shows the percentage of subjects successfully discriminating the two kinds of rotations offered in the tests. It is evident that the vertical-horizontal rotation offered only a modicum of difficulty for the youngest children, while the oblique rotation was quite confusing through the third grade group. These data suggest that at least one aspect of the

Figure 3



discrimination of orientation must be largely complete for these children by five years of age, while another aspect has hardly begun.

Bender-Gestalt items. The Bender-Gestalt test is a test where line figures are copied. The test rests upon observations by Lauretta Bender that organic patients show characteristic distortions in copying drawings, and it is used in the diagnosis of organicity for adults. Koppitz (1960) showed that young children characteristically show "organic" scores, with marked improvement in their drawings between five and seven years of age. Three of the Koppitz designs were used in this study, those three that seemed on the basis of her data to be most directly sensitive for the changes in children's performance.

There is no clear line of analysis in existence discussing the meaning of the changes observed with age. There are marked drawing difficulties associated with parietal damage in adults, and such drawing difficulties are termed 'constructional apraxia' by neurologists. Since there is some indication that parietal myelinization completes itself at about five or six years of age (Milner, 1967), one might be inclined to believe that the Koppitz data reflects a decline in a constructional apraxia that is normative to children before five years of age. However, children show some difficulties in sustained, efficient, task-directed behavior in contexts that one would not associate with neurological diagnosis. We will not know without further experimental analysis how much one can assume a neurological interpretation of data on the copying of figures.

Data obtained with the Brookline children generally accorded with Koppitz's findings. The scoring followed hers, with ratings for distortion, integration, rotation, and perseveration in the drawing of the figures. Generally, more favorable scores were obtained the older the children were, with the most marked improvement between N and 1 (Figure 4).

Three interrelated factors seem to be implicated in Bender-Gestalt performance: memory for designs, ability to perceptually organize the figures, and motor skill. After completing their drawings of the Bender-Gestalt specimen figures from memory, the children were then given tracing paper and asked to copy the figures by tracing. Their drawings were then rated to judge whether they reflected an apparent awareness of the total organization or "gestalt" of the figures. Results are pictured in Figure 5. The tracings were also rated for accuracy, with such ratings presumed to reflect motor coordination. Results for these ratings are pictured in Figure 6. On the whole, the results for Figures 5 and 6 would tend to suggest that one does not have to posit memory loss or distortion to explain the data of Figure 4. What seems to be developing in the children at this time as a basis for Bender-Gestalt performance is some factor of perceptual organization and some factor of motor skill.

Construction of a Diagonal. One of the somewhat puzzling phenomena of the preschool period is the inability of the preschool child to draw or construct a diagonal successfully even though he clearly recognizes the diagonal. This disjunction is one of a number of perception-performance

Figure 4

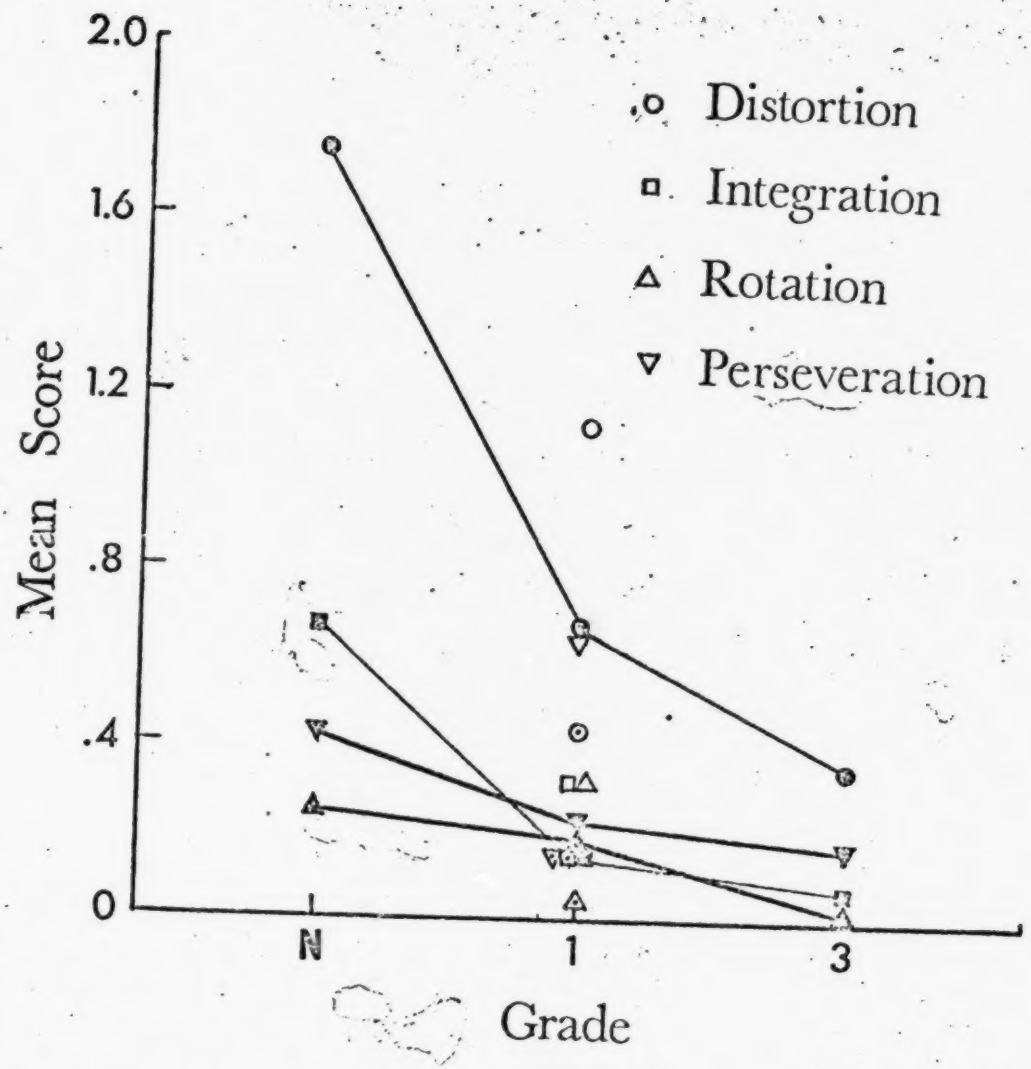

2.0
1.6
1.2
.8
.4
0
Mean Score
N
1
3
Grade
Distortion
Integration
Rotation
Perseveration

Figure 5

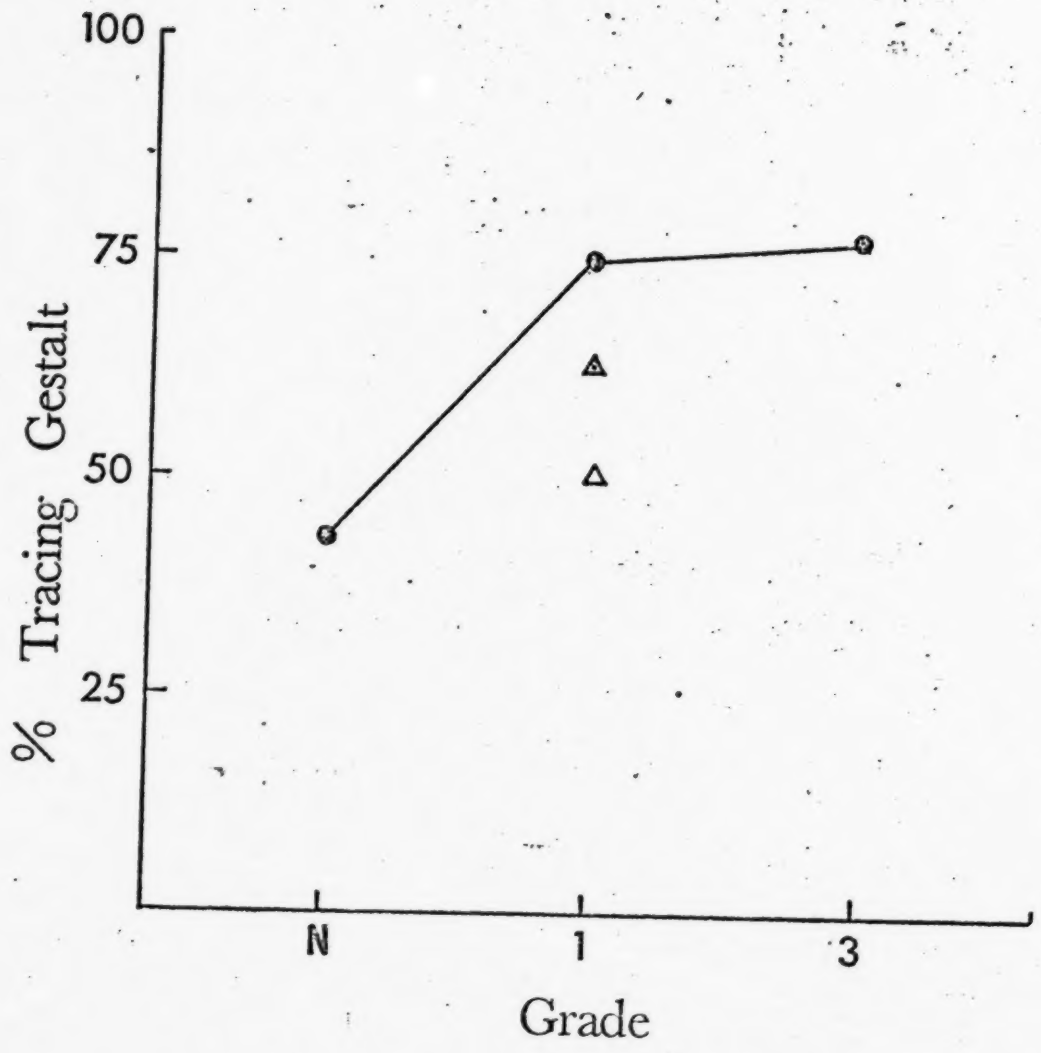
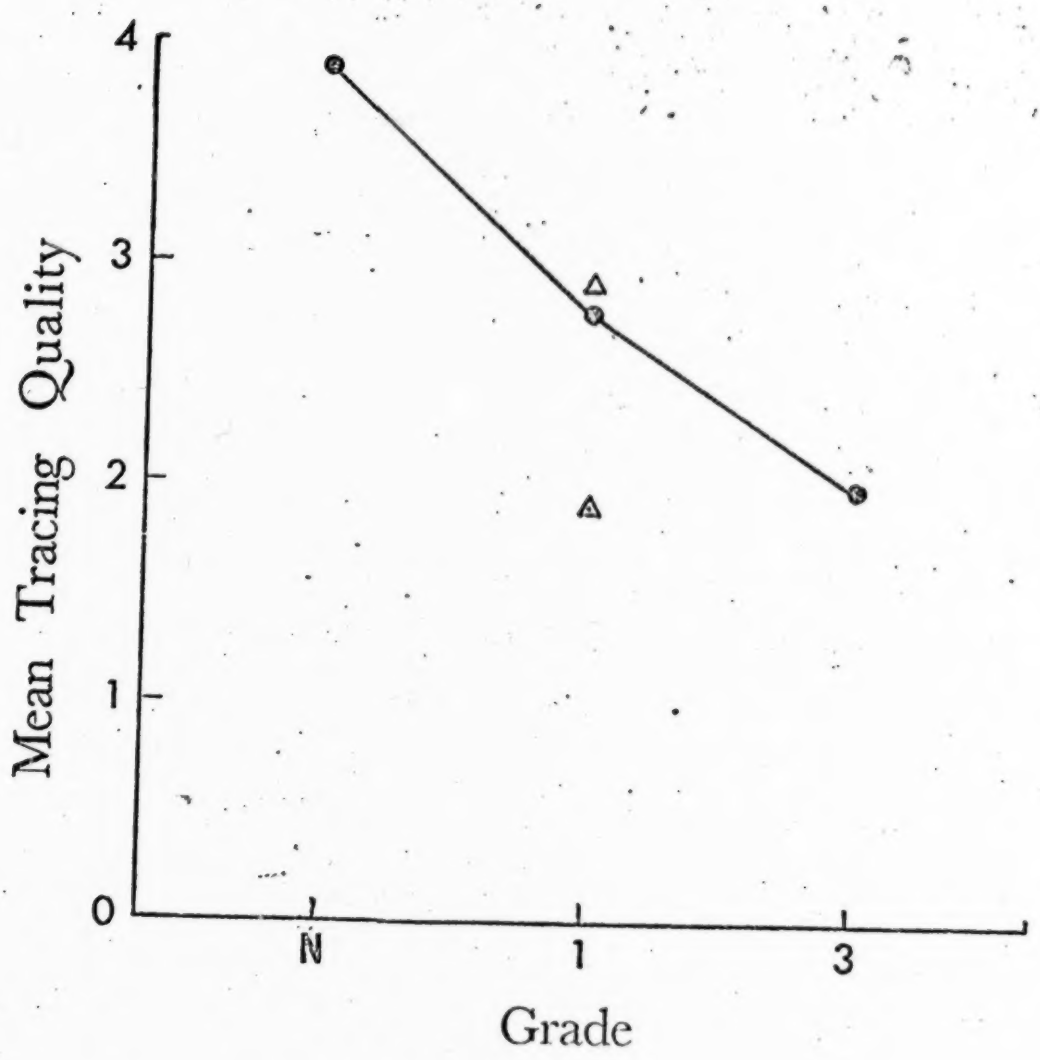


Figure 6



disparities in early childhood, cases where a child seems to know something in one way but not in another. Generally, children become able to construct a diagonal at 5 or 6 years of age. There has been relatively little study of this developing ability in children, but at the time we began this series David Olson was conducting a five-year program of investigations that has now eventuated in a monograph (Olson, 1970). We included a procedure in which the children were asked to copy a diagonal using pencil and paper. For children in our last Brookline sample, about 60% were able to reproduce the diagonal correctly at nursery school level, and about 95% did so successfully at first and third grade levels. This age trend is consistent with that found by Olson (1970).

Right-left Discrimination. Children generally become able to tell their right hand from their left hand at about six years of age. Considerable importance has been attached to this by some writers because the act of successful right-left discrimination has been felt to be a milestone in lateralization of function and in the organization of a coherent body scheme. Since the writings of Samuel Orton in the 1920's, it has been felt that right-left confusions have an integral association with reading problems and other disorders of symbolizing. Furthermore, there is evidence that right-left confusion in adults is a frequent concomitant of aphasia.

Piaget has written about right-left discrimination not as a manifestation of neurological organization but rather as an important step in the child's organization of a private framework of objective Euclidean space. Piaget has noted that the child's coming to tell his left from his right is only a step towards an objective spatial framework. At age 6, the child cannot yet discriminate the left and right of someone facing him. He makes the differentiation, but only in an egocentric spatial framework. It is only when the differentiation can be made from someone else's point of view that one can argue that the child has an objective framework.

The testing included a procedure that probed the child's ability to respond to right-left questions and explain his responses in terms that suggested he had an objective understanding of space. The child was asked to show his right hand and his left hand. If he could not do this correctly, he was asked to "show the hand you eat with." When an adequate designation had been arrived at, either the terms "right" or "left" or functional terms, the child was then asked to point out the same hands on a toy doll facing towards him and facing away from him. The results of this inquiry are shown in Figure 7. Answers that were "consistent with self" were, in ordinary terms, correct answers. Each time, after the child pointed out a hand in response to a question, he was asked, "How do you know?" If the child explained his answers in terms that indicated that he understood that terms like "right" and "left" applied with respect to the orientation of the object, he was judged to have an objective rationale for his responses. Figure 8 gives percentages of the Brookline sample that were judged to have an objective rationale.

Figure 7

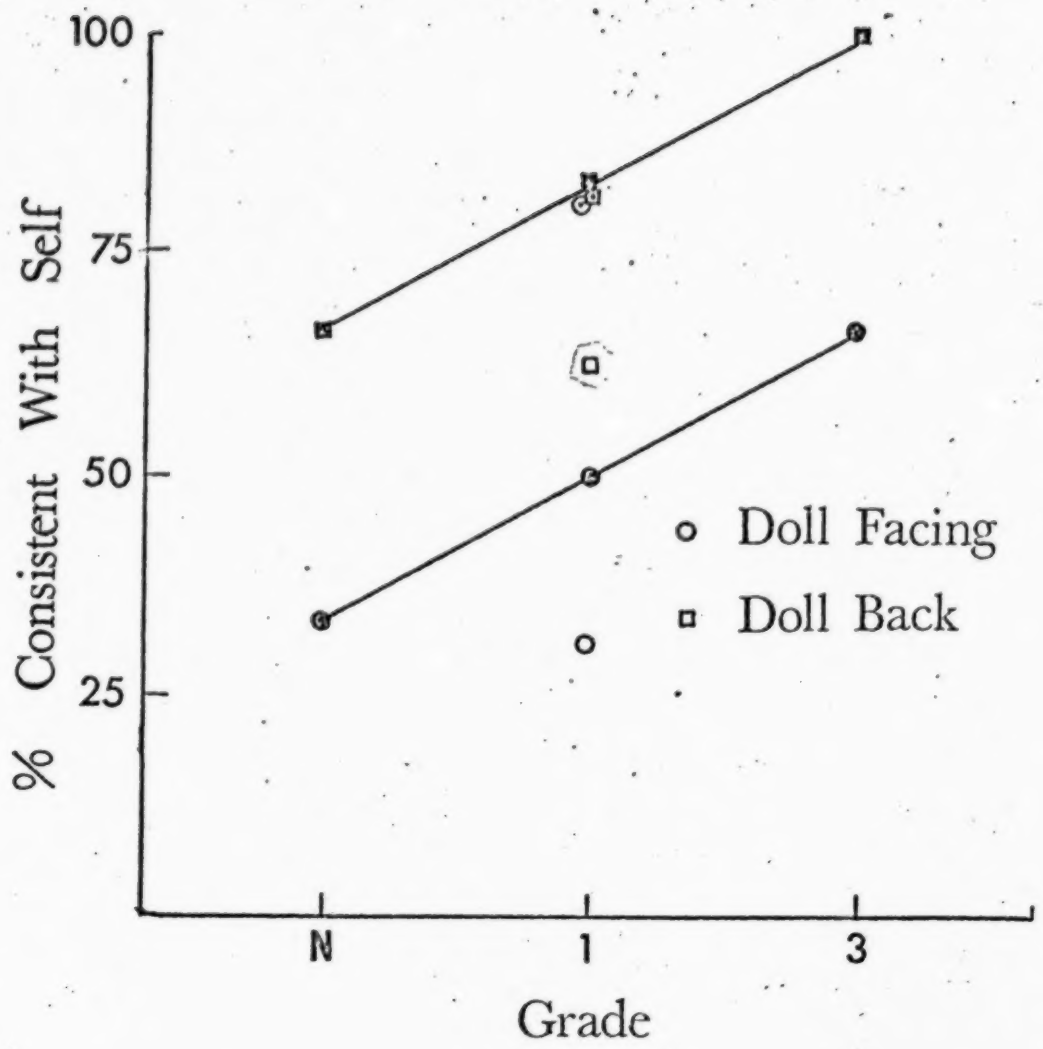
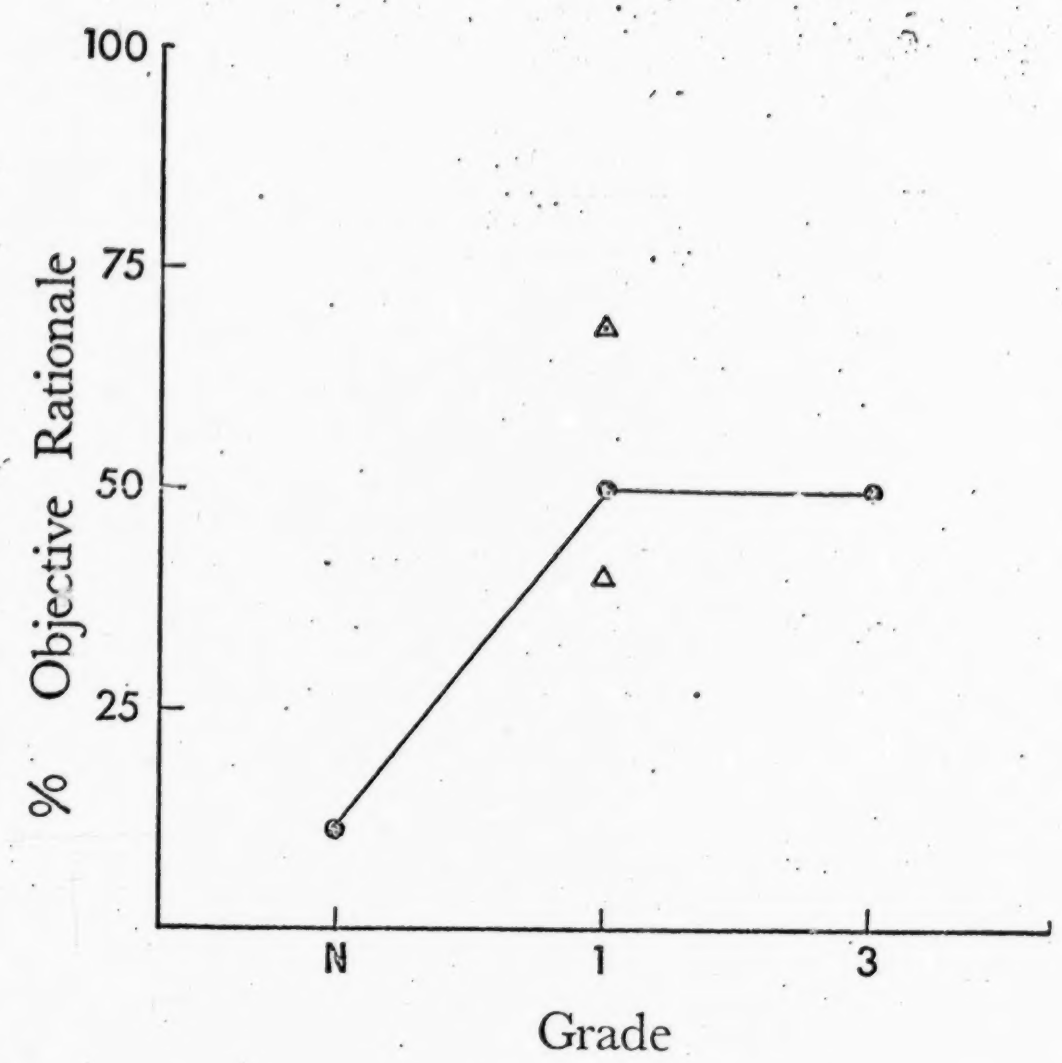

100
75
50
25
% Consistent With Self
N
1
3
Grade
Doll Facing
Doll Back

Figure 8



The results of the left-right testing were consistent with expectations from previous reports. It is noteworthy that only about half of the older children could give an explanation that was deemed sufficient by judges to indicate presence of an objective rationale. This was roughly consistent with the numbers of children able to make a correct choice with the doll facing them.

Drawing Maximum and Minimum Squares. A fairly simple procedure was included following an experiment by Rey as given by Piaget (1960c, p. 37). The child is given a piece of paper with a standard square upon it and he is asked to draw the largest and smallest possible squares on the piece of paper. Children over 7-8 years tend to draw a very tiny square and a square following as close to the edge of the paper as possible. Children younger than 7 tend to draw two squares slightly larger and slightly smaller than the standard. The Rey experiment is offered by Piaget as an example of an acquisition of the onset of the period of concrete operations. With the coming of concrete operations, the child is able to use "asymmetric relation groupings." The child becomes able to see the perceived figure as a member of a class of like figures with a great range in sizes.

A procedure modeled upon Rey's was included in the test battery and the figures to follow show the data for the Brookline sample under discussion here. Figure 9 shows the median area for the larger squares drawn by the children and Figure 10 for the smaller. The data confirm Rey's observations. Generally, the children progressed from squares drawn closely around the standard offered them towards maximal and minimal squares as adults would tend to draw them.

As an index of the visual-motor skills of the children, analogous to some of the scorings of the Bender-Gestalt items, some additional scorings were made. The larger and smaller squares were measured for concentricity with the standard square, with results pictured on Figure 11. In addition, the quality of the childrens' drawn squares as squares was scored, with results pictured in Figure 12. From these latter two scorings, it seems reasonable to conclude that there were noticeable improvements in the skills with which the children made their drawings. It is not clear that these skill improvements explain the Rey phenomenon. They seem more likely to be an auxiliary development. On the surface at least, the most likely explanation for the size choices made by the children might be some such explanation as that offered by Piaget.

Brothers. Another fairly simple Piagetian item was included in the battery, this one suggestive of the child's ability to form "class inclusion groupings" with the coming of concrete operations. The child is asked about his brothers and sisters. He names them. He is then asked how many brothers and sisters he has, and how many brothers and sisters each of his sibs has. With the coming of concrete operations, the child comes to understand that he must be counted as a brother or sister for his sibs.

Figure 9

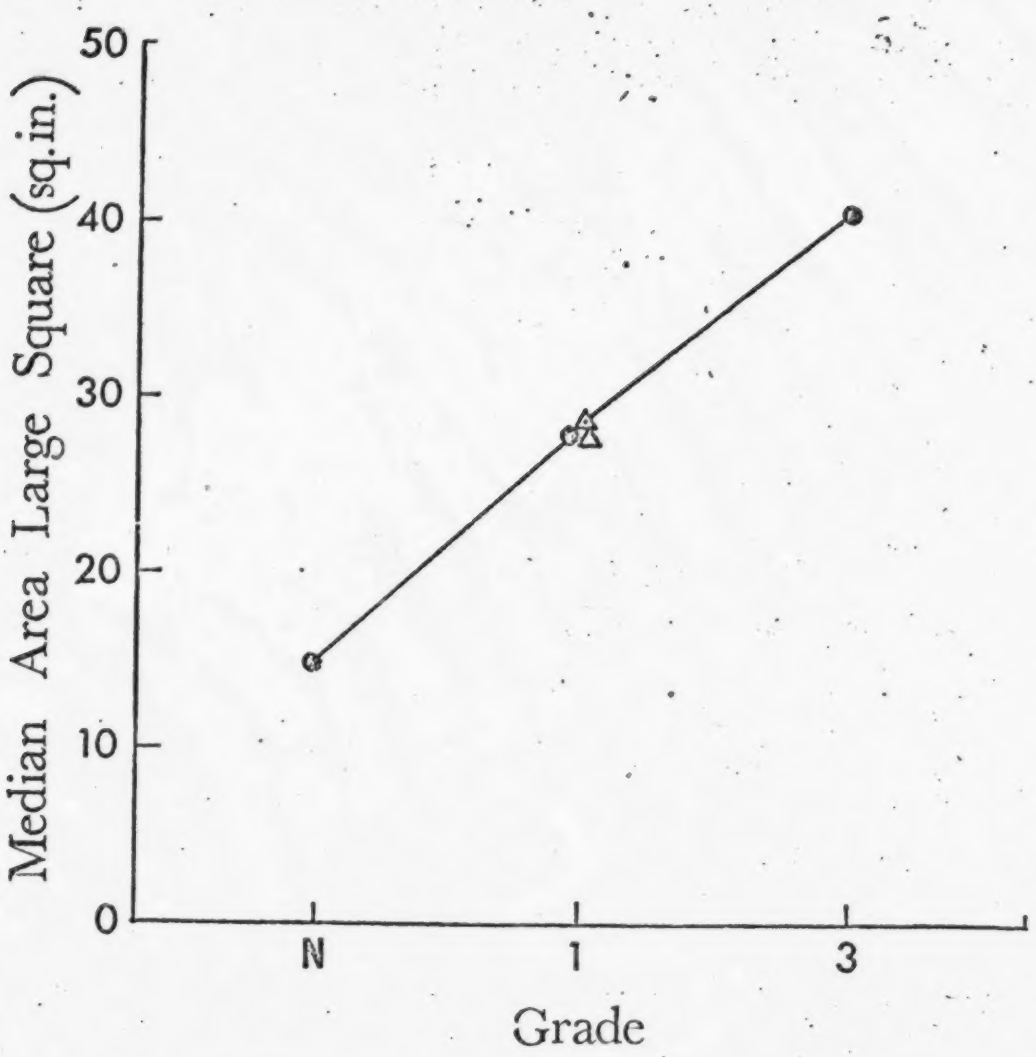


Figure 10

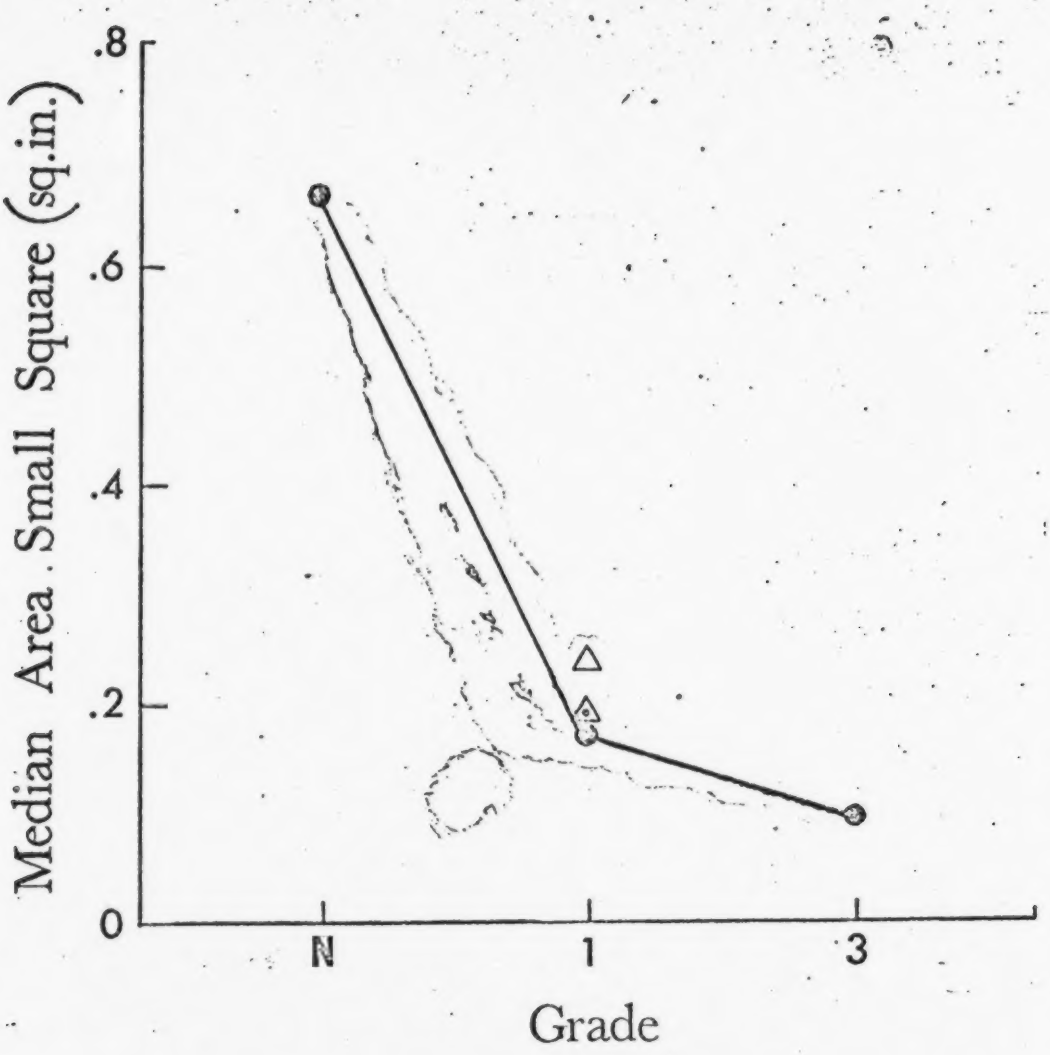


Figure 11

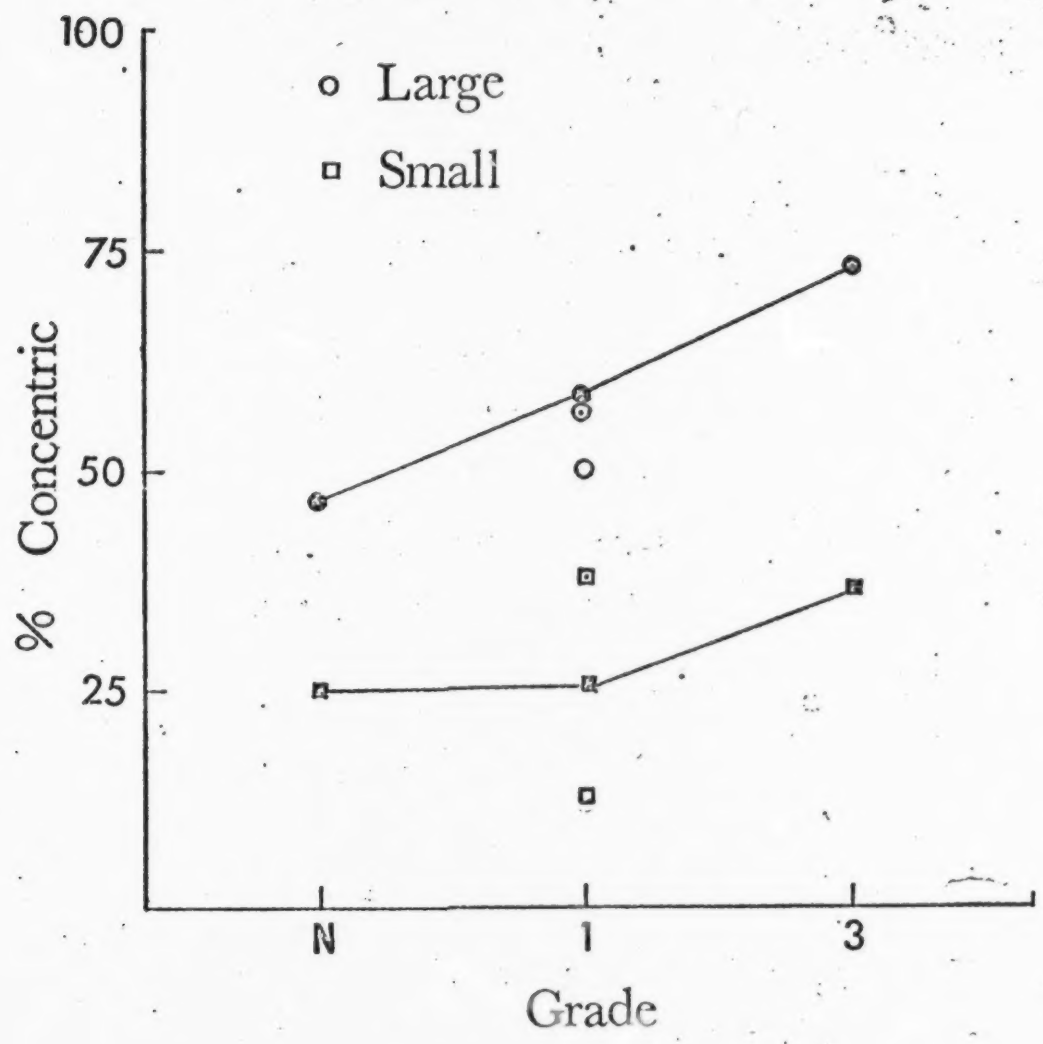


Figure 12

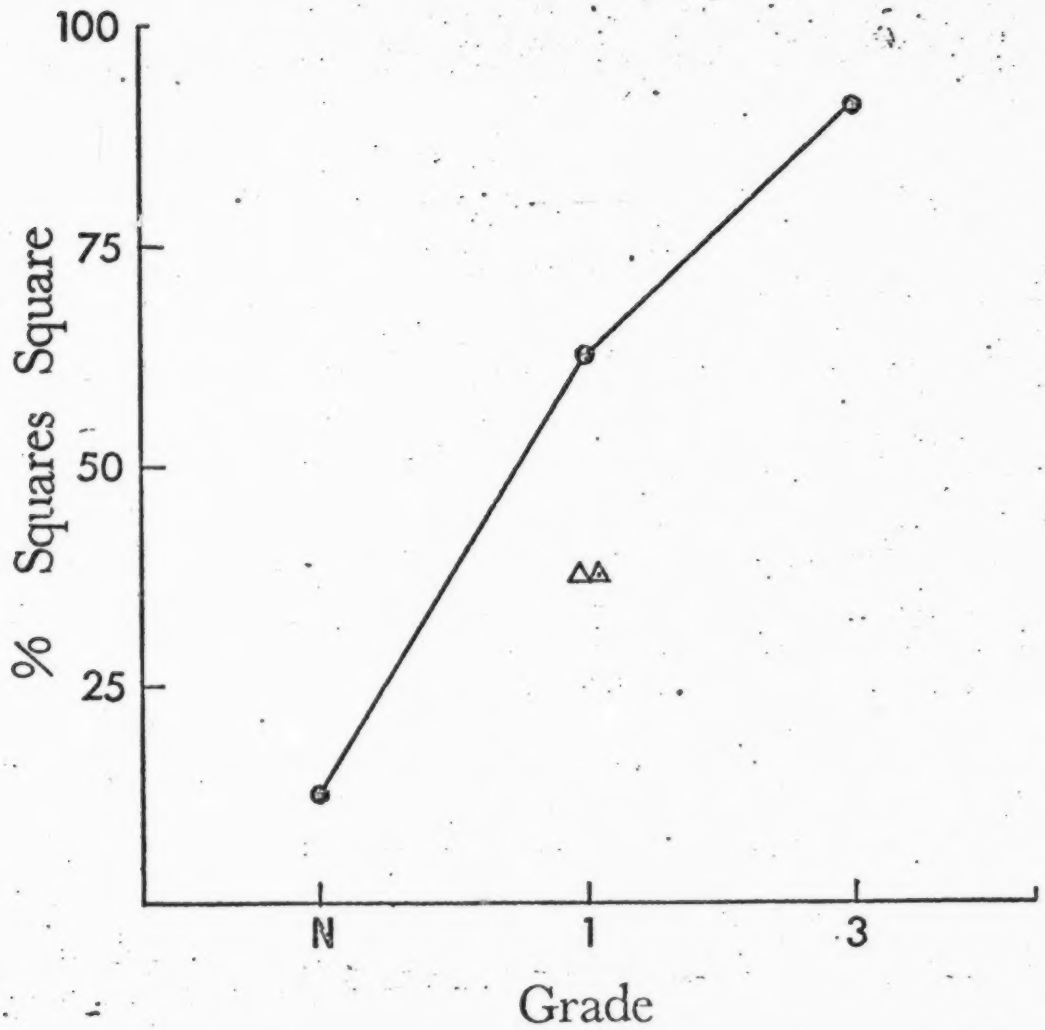


Figure 13 shows the scorings of data for the Brookline sample. An egocentric response pattern was one where the child failed to include himself as his sibs' sib; a mature pattern was one where he clearly did so include himself; a pattern labeled 'other' was a mixed or indeterminate pattern. The pattern of results is consistent with that to be expected from Piaget's work, although the evidence for transition is somewhat weaker than one might have expected.

Trapezoid Illusion. An important development in the 5-7 age range is the group of "conservations" studied by Piaget. An interesting test of the presence or absence of size conservation has been studied by Charlesworth (1967). In general, Charlesworth's work has been concerned with the indirect study of the acquisition of cognitive expectations about the world through the study of the presence or absence of surprise when expectations are violated. Charlesworth's study of preoperational children used a demonstration of the trapezoid illusion, and a procedure was incorporated into the battery based on his. If two same-sized trapezoids are viewed one above the other, there will usually arise an illusory judgment that the top one is larger than the bottom one. The viewer tends to be biased by the fact that the long bottom line of the top trapezoid is adjacent to the short bottom line of the bottom trapezoid.

The trapezoid procedure developed in our studies was one in which the child was shown a trapezoid of one color over a same-sized trapezoid of another color. After the child chose the top one as larger, the up-and-down positions of the two trapezoids were reversed in sight of the child and he was again asked which one was larger. Ratings were made for indications of surprise when the reversal was executed.

This procedure was an addition to the battery for our last Brookline sample, the one whose data are being presented here, and the evidence coming from this group and from subsequent African and Weston samples indicated that it did not work particularly well. Figure 14 gives Brookline data for the percentages of children at each age who shifted judgments after the illusion was reversed. One would generally, from Piaget's reasoning, expect the youngest group to show a higher percentage of shifts in judgment after the reversal (because they are more guided by the perceptual or the immediately-given). This did not occur, quite possibly because there may be a tendency for younger children not to be susceptible to the trapezoid illusion to the same extent as the older children. Another aspect of Piagetian theorizing, his developmental analysis of perception, holds that as children grow older they become more and more capable of visual 'decentering' and consequently more susceptible to some illusions and less susceptible to others. It is possible that the trapezoid illusion is one that increases in power with age, but Pick and Pick's (1970) recent review of age changes in illusion strength does not mention this one. Figure 15 shows the data for the ratings of surprise in the three age groups and these data are modestly consistent with expectations from Piaget and Charlesworth. There is a trend towards more evidence of surprise as children are older. Not all children show the kind of dramatic,

Figure 13

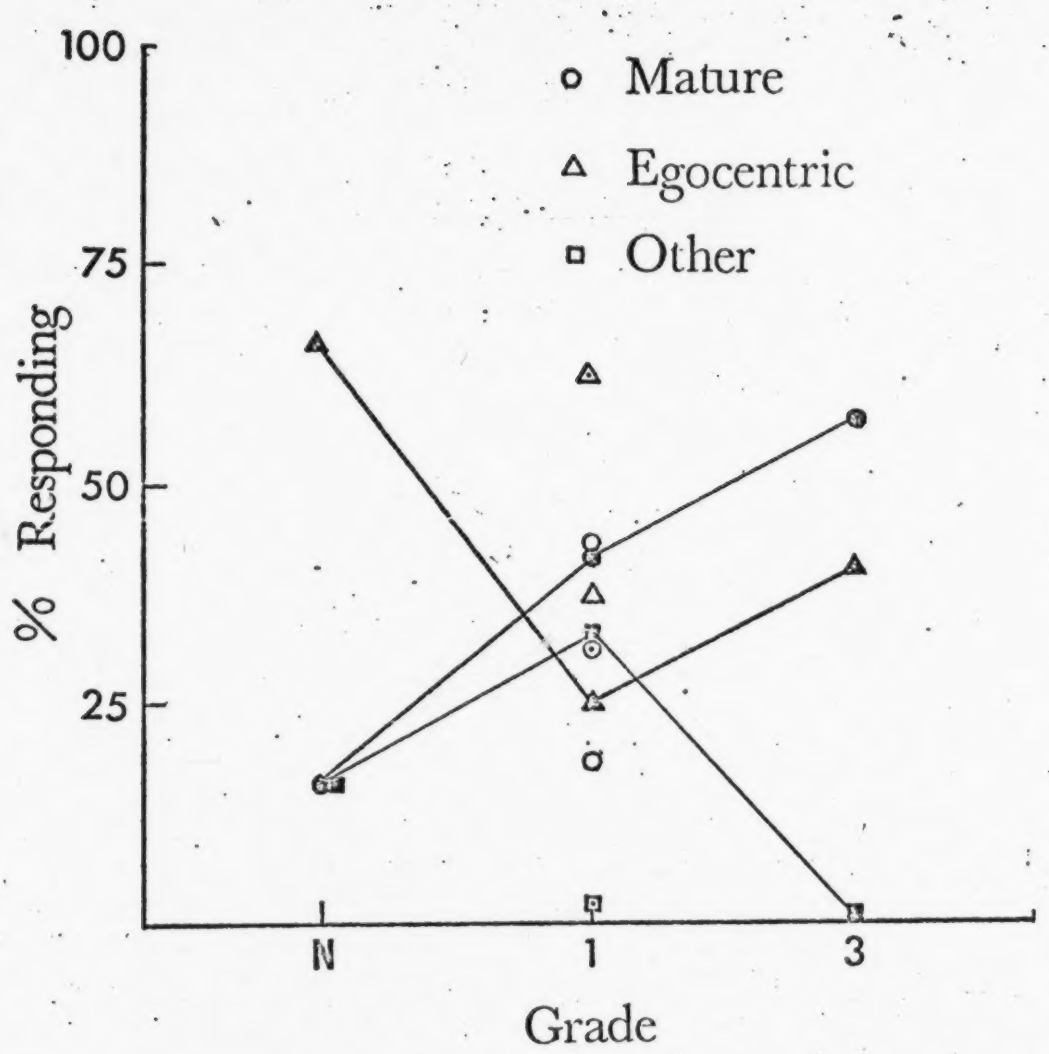


Figure 14

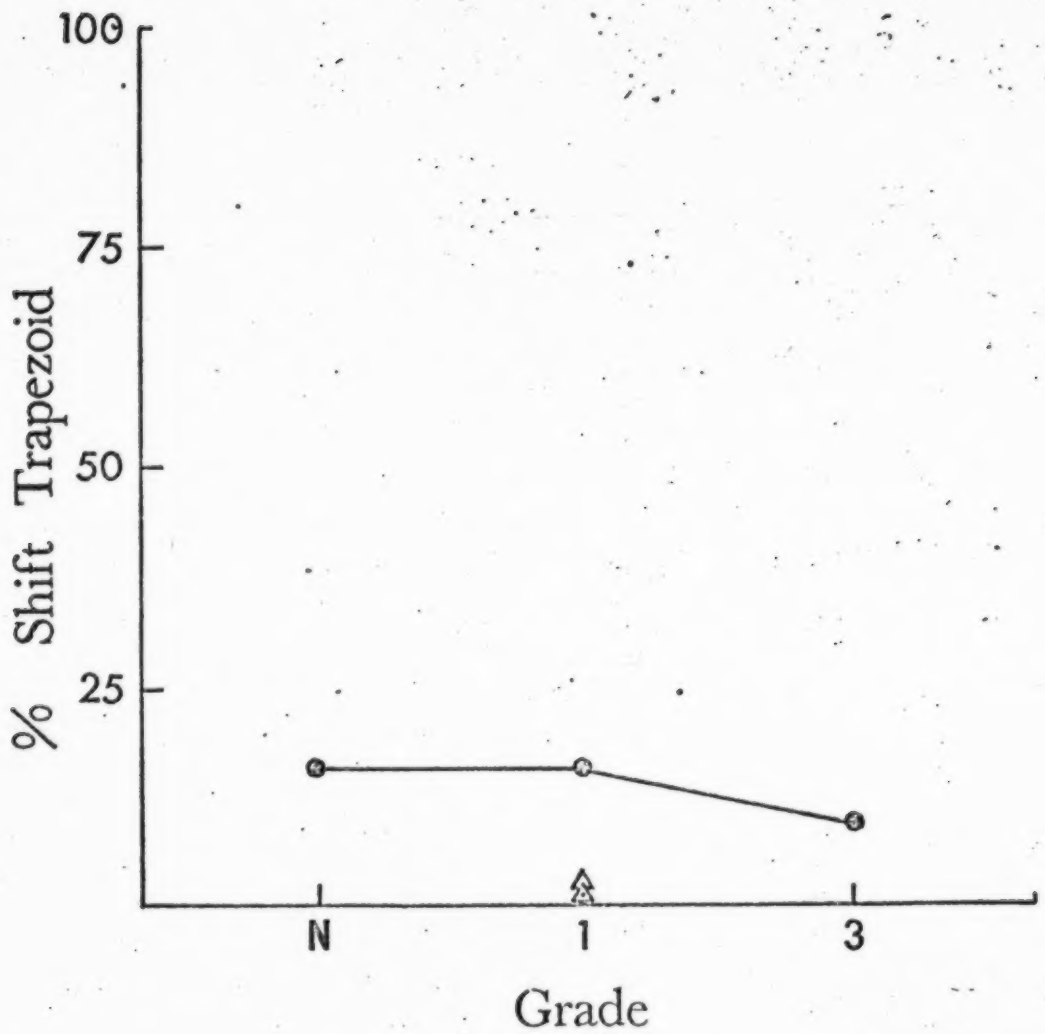
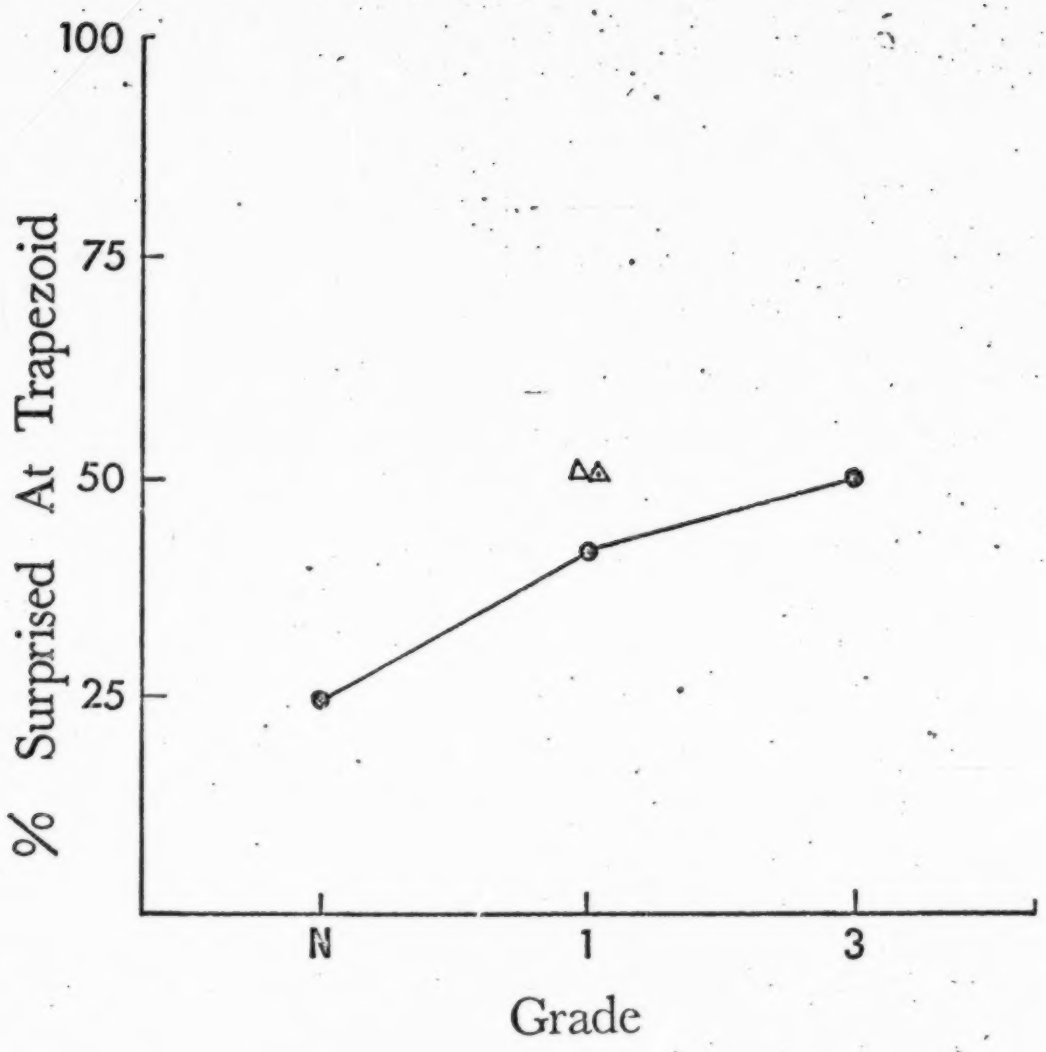


Figure 15



extroverted surprise that might be captured by a rater and it seems most likely that what is manifest in the figure should be regarded as sampled evidence. Of course, one could argue that this developmental trend could be an expression of a growth in strength of the illusion upon which the surprise depends.

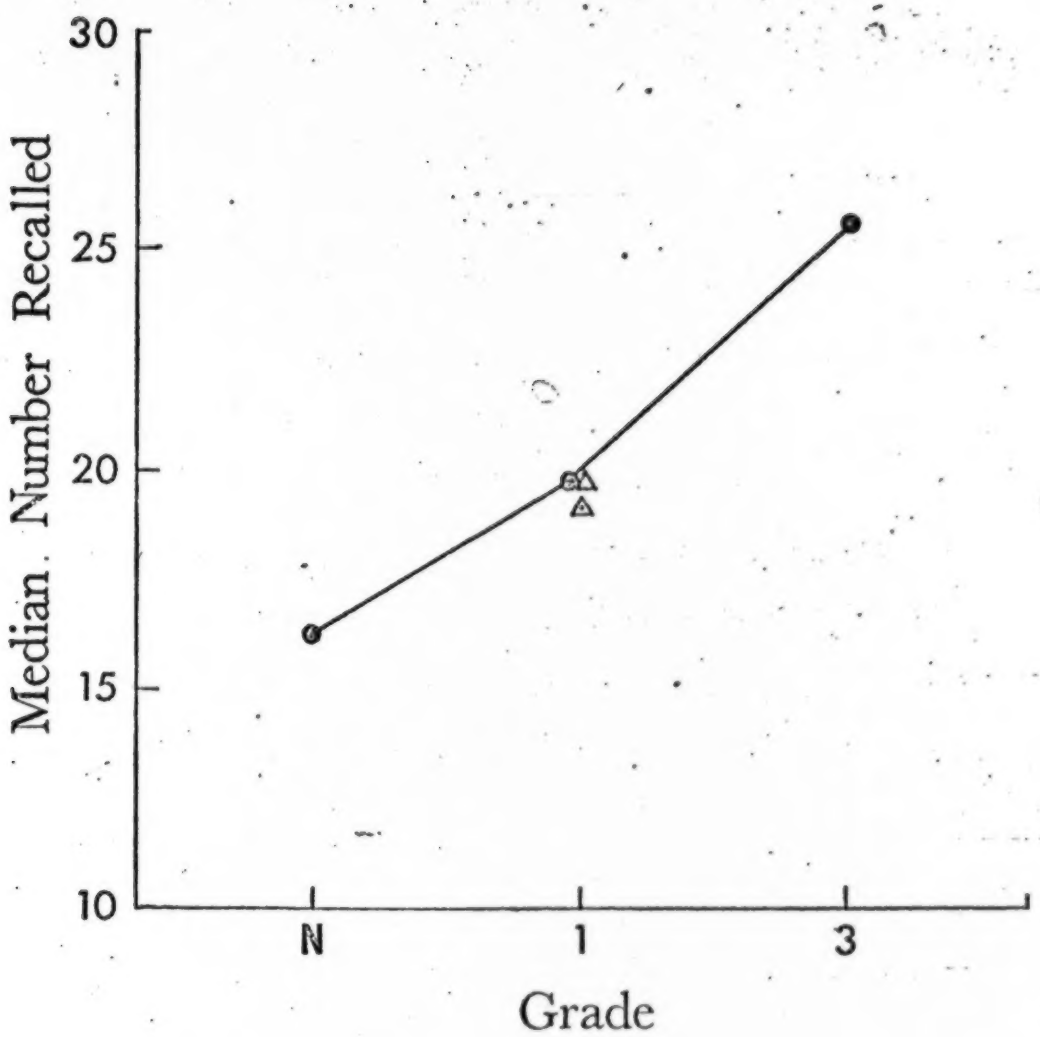
Picture Recall. One of the original items included in the battery was a task in which an array of pictures was placed before the child and he was asked to sort them. The pictures were line drawings of concrete objects. Annett (1959), in a rather well-designed study, has reported several kinds of age trend in the way in which children tend to group the pictures. The age trends seemed suggestive about the way in which children categorize or conceptualize objects. During the development of the battery, interest shifted towards tests of recall of the objects because of the possibility that clustering during recall might be a more direct measure of concept usage less complicated by some of the mechanical issues that arise when children are asked to physically manipulate pictures. Clustering occurs when subjects tend to deliver their recall of a set of items in sequences suggesting that they have internally grouped the objects by category.

In previous studies in this series, pictures were given to the children in a mixed array on a table and the children were asked to put together those pictures that go together. These pictures were modelled upon Annett's pictures and, generally, data obtained had been consistent with expectations from Annett's work. In the Brookline study under discussion here, the presentation had been modified to try to get at clustering in memory. Thirty pictures were placed one by one on the pages of a book. The children were shown the pictures and asked to name them. Then, after a brief interval, the children were asked to recall the pictures in the book.

We had expected that clustering indices would increase with age, following Bousfield, Emerson, and Whitmarsh (1958). We found no age trend in this sample, although we did find a strong age-increase in recall (Figure 16).

Face-hand Test. The face-hand test was developed by Bender, Fink, and Green (1951) as an indicator of brain damage, and was then subsequently shown to change with age (Fink and Bender, 1952). The name of the test is somewhat of a misnomer because the issue is the general ability of the subject to register two simultaneous touches, one more proximal and one more distal. One pair of proximal and distal skin sites is the face and hand but other pairs give a similar pattern of response. Before six, the child touched simultaneously on the face and hand will report only the touch on the face. After six, he will report the sensation of both touches simultaneously. It is interesting that patients with brain damage tend to revert to the more juvenile pattern as, also, will the normal aged.

Figure 16



If an adult experiences the test, he will feel what is probably the basis for the children's inability. The more proximal of a pair of touches feels much stronger and more salient, and conceivably could be dismissed as a negligible detail of the experience. The inability to register the two touches is not absolute. If one continually re-stimulates a pair of sites the subject has a tendency to gradually become aware of the more distal site. For this reason, Critchley, in his book on parietal lobe disorders, tends to characterize the test as one of "selective inattention."

Children were stimulated with a pair of aesthesiometers in the following order: right cheek; both hands; right hand and right cheek; left hand; right hand and left cheek; left hand and left cheek; right hand; and left hand and right cheek. Each time, the child was asked to indicate where he had been touched and, after responding, asked "Just there, or also a second place?".

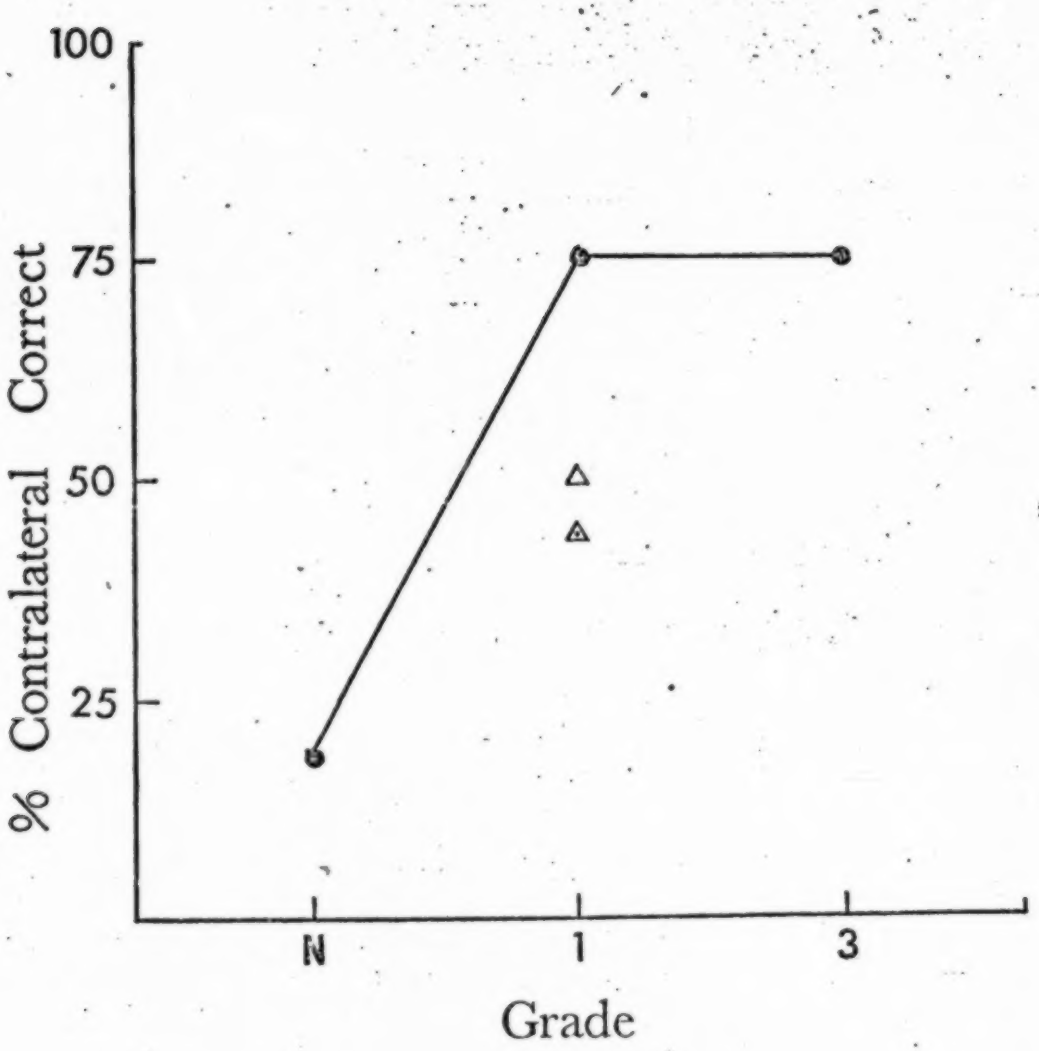
Figure 17 shows the percentage of correct responses obtained for each of the age groups in the Brookline sample under discussion. The figure gives an age curve for correctness on contralateral stimulation (e.g., right hand and left cheek). Data in this series, and in the African study, suggest that ipsilateral correctness (e.g., right hand and right cheek) occurs somewhat later.

Signal Detection Task. A signal detection task was devised by Charles Super for inclusion in the battery, capitalizing upon his analysis of dichotic listening experiments with children by Maccoby and Konrad (1967). Their data seemed to suggest a somewhat marked decrease in intrusive errors in the 5-7 age range and the phenomenon seemed worth studying in the project effort.

The child was shown a sheet of paper with eight drawings of common objects and asked to identify each picture given its name. With the names of the objects established, the child was given earphones and followed a tape-recorded procedure. He would hear a male or a female voice say, "Point only to what I say" and then different objects were designated by the male and the female voice speaking simultaneously. The child's task was to follow the instruction of only the pre-designated voice. Following the instruction of the other voice was scored as an intrusion. There were sixteen test trials.

Figure 18 shows data for the three age groups under discussion here. There was a marked increase in the ability of the children to select only the predesignated voice and to resist intrusions. Little theoretical meaning can be assigned to this age trend in selective auditory attention. It resembles findings for children's use of visual stimuli at this age, suggesting that children become better able to screen out unwanted or background visual "noise" (White, 1966). However, one needs somehow to reconcile such findings with the age trend just discussed for the face-hand test, where the implication seems to be that older children become more sensitive to peripheral stimulus material. Some experiments will be

Figure 17



discussed below in which attempts were made to create graded amounts of visual "noise" and to systematically explore children's ability to deal with peripheral cue material. But there has been very little systematic work exploring children's ability to attend in either the visual or auditory modalities and there are few theoretical leads into the finding of Figure 18.

Delayed Auditory Feedback. The phenomenon of speech disturbance with delayed auditory feedback is fairly well known among adults. If the circuitry of a tape recorder is altered so that a person's voice is fed back to him through earphones at a constant fraction of a second delay, there is a strong tendency for this to cause speech disturbance. Speech slows. There are hesitations and prolongations and, often, studying. The speaker will often raise the loudness of his voice in an effort to drown out the disruptive sounds he hears through his earphones.

Chase et al. (1961) had conducted an experiment in which they used delayed auditory feedback with children, and they had reported that children 4 to 6 years of age were not affected by it but children 7 to 9 years of age were. This was an isolated finding, and at this writing it has received little follow-up, but the finding seemed theoretically interesting. It was reminiscent of arguments advanced by both Russian (Vygotsky, 1961) and American (Kendler and Kendler, 1962) psychologists to the effect that children's language becomes significantly more self-directing at about age 6. The Chase et al. finding seemed to suggest an almost too-simple explanation. The younger children were somehow not listening to themselves speak, not registering what their voice was doing.

Children were given a series of tasks requiring spoken replies. They were asked to repeat a series of words and pictures and to name the pictures used in the signal-detection task. They did this once with the tape recorder giving simultaneous auditory feedback and once with the instrument set to deliver delayed auditory feedback. Measures of speech disruption through delay could then be made by comparing the voice qualities of the child speaking over delay versus his voice quality when speaking over simultaneity.

A number of indices of speech disruption were used in analysis of the delayed auditory feedback data. Generally, results were consistent with the premise that delayed auditory feedback gives children more trouble as they get older. But the delayed auditory feedback we used influenced even the youngest children, causing them to speak more loudly. Other kinds of voice distortions were found to be accompanied by idiosyncratic strategies different individuals used to try to get around the interference of the played-back voice. Figure 19 shows the tendency towards increased loudness at the three ages. Figure 20 gives data for an increase in time taken to speech, and Figure 21 gives data for an index of prolongations of speech.

After these data were collected, some findings appeared which seemed to cast a different light on the delayed auditory feedback phenomenon and which might serve as a basis for understanding the somewhat peculiar age

Figure 18

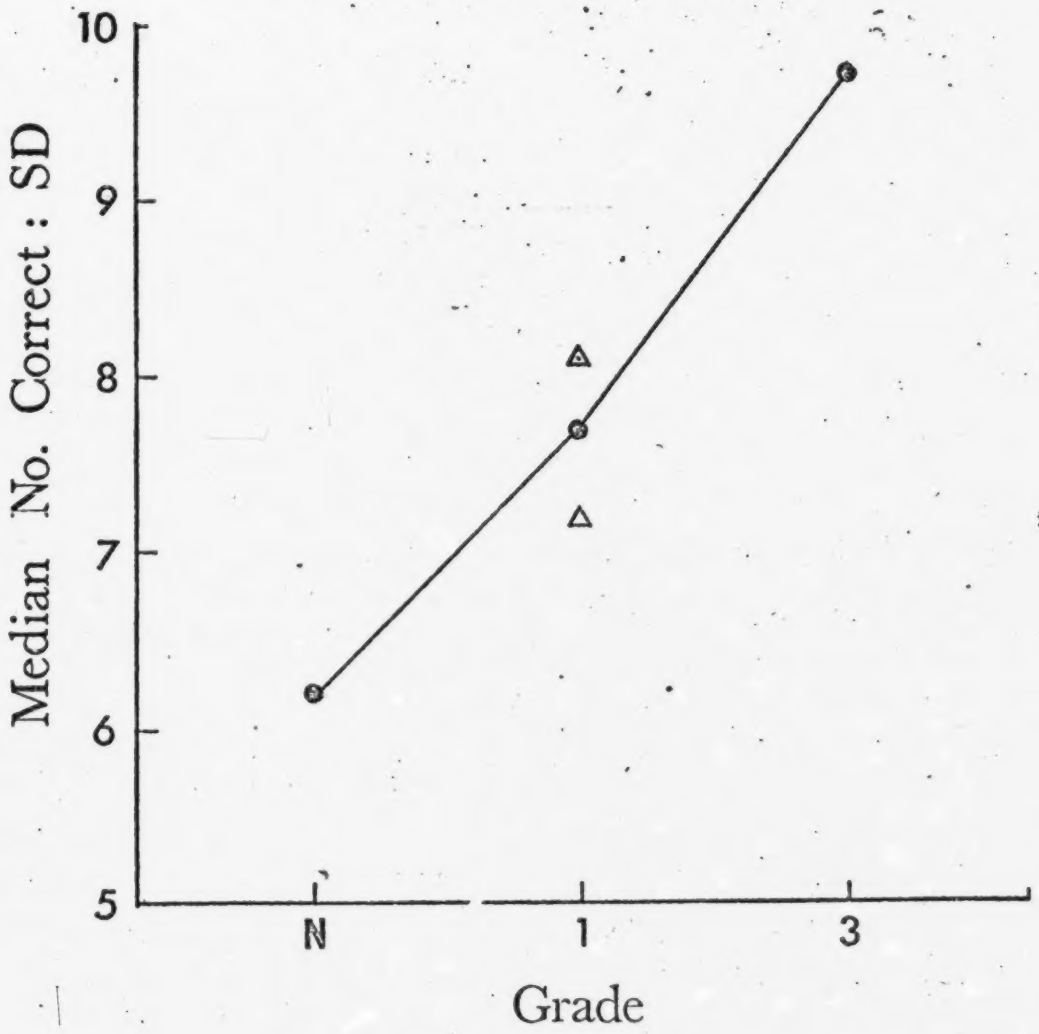


Figure 19

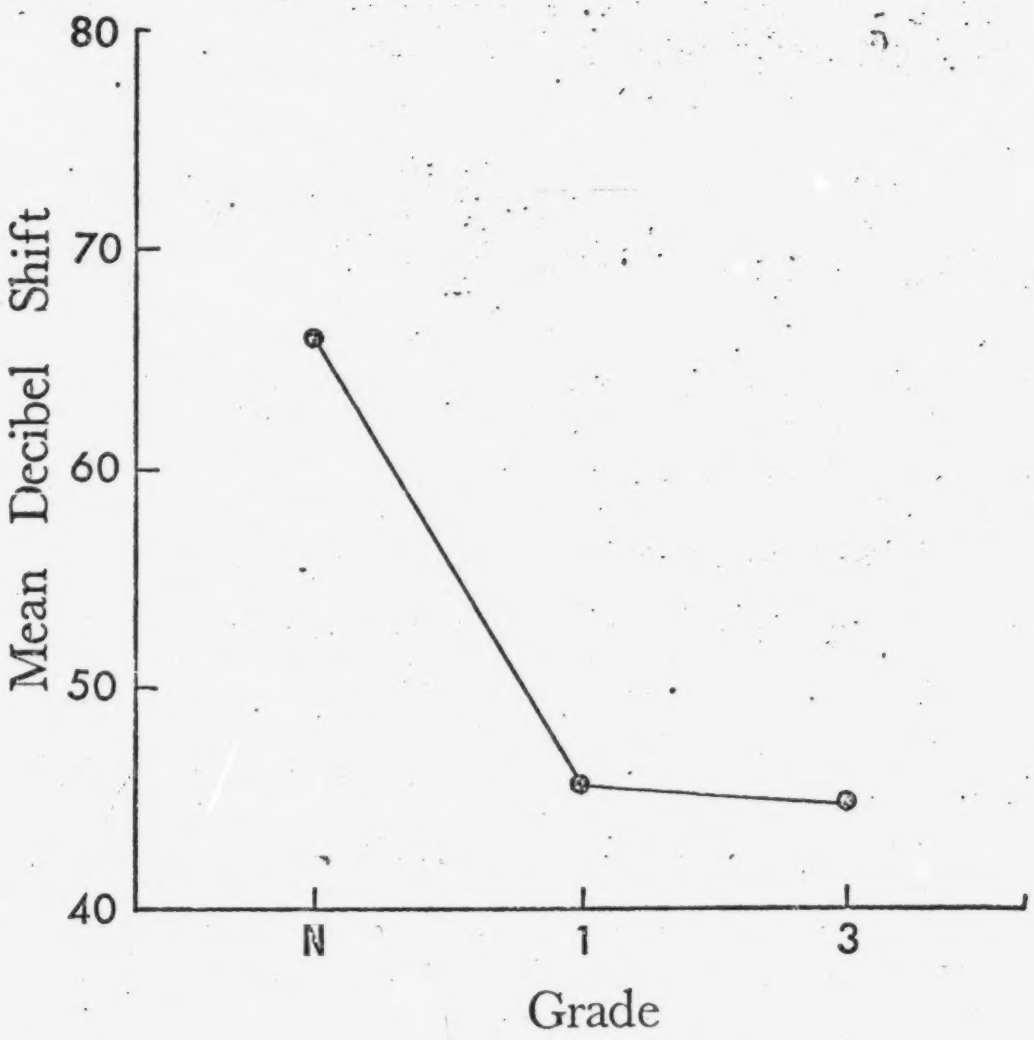


Figure 20

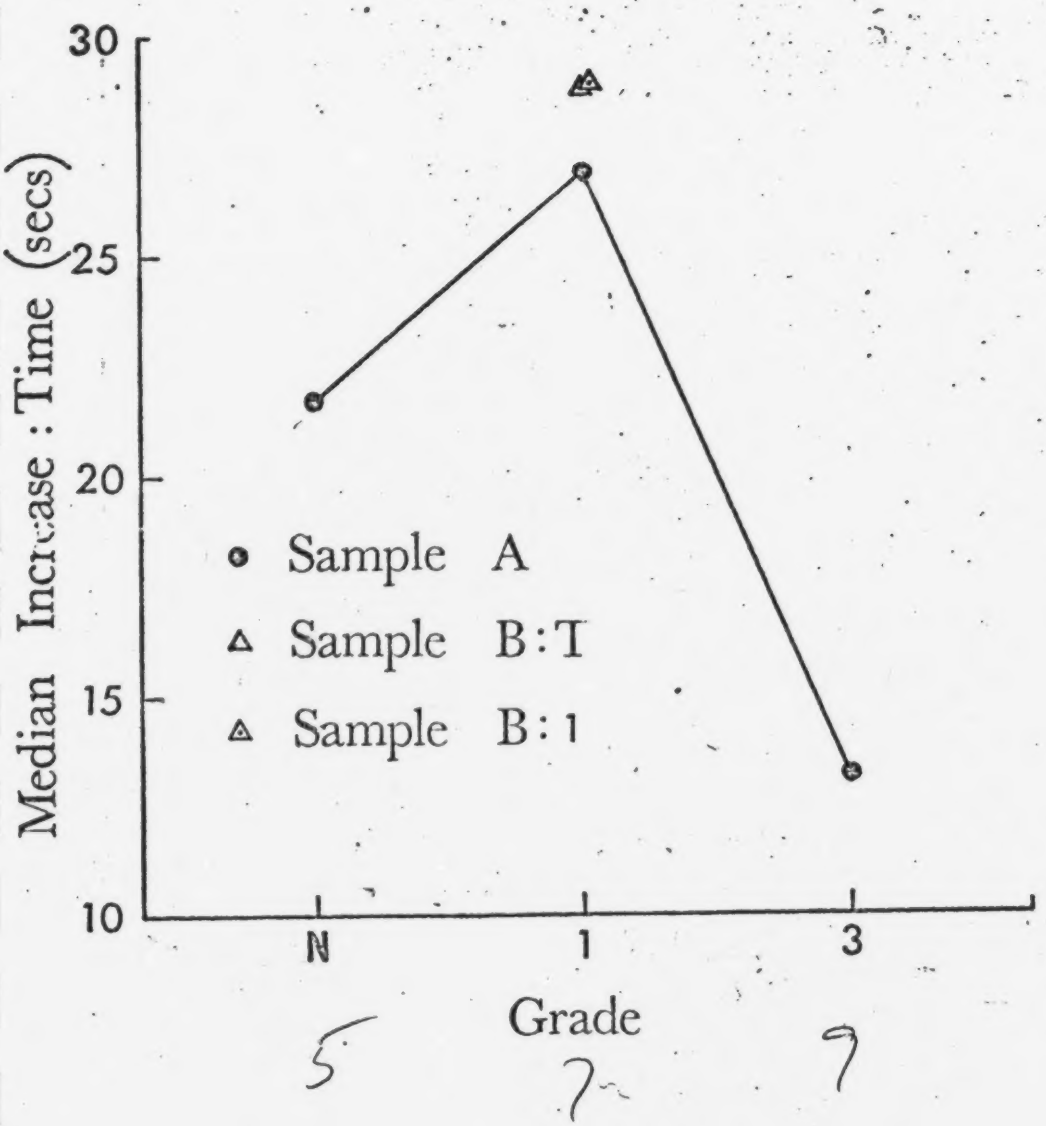
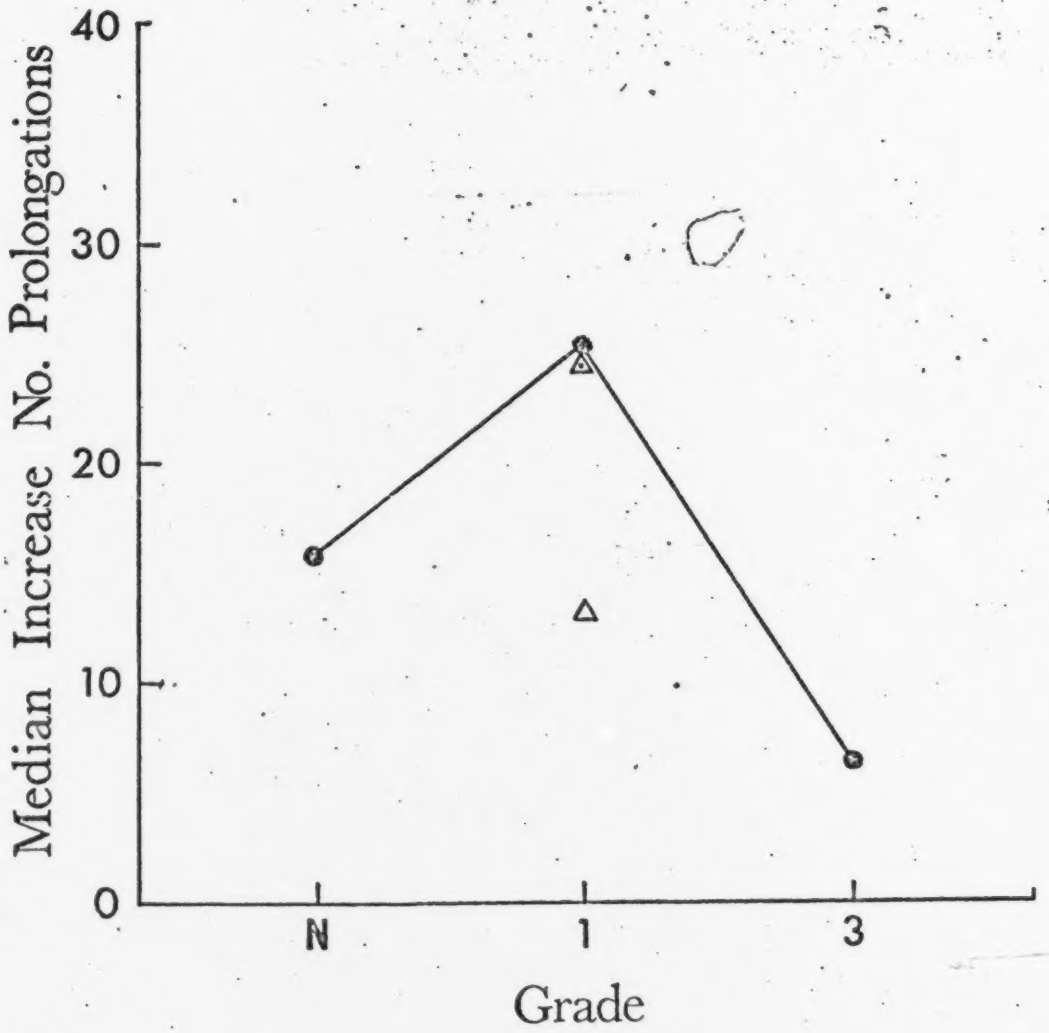

30
25
20
15
10
Median Increase : Time (secs)
Sample A
Sample B:T
Sample B:1
N
1
3
Grade

Figure 21



trends we obtained. Delayed auditory feedback studies are often conducted by making a simple modification of a standard tape recorder with separate recording and playback heads. The recorder is rewired so that the playback head, operating during recording, plays out to the subject's earphones. The feedback interval thus obtained is a function of the mechanical arrangement of the tape recorder and, as it happens, this interval produces disruptive speech effects in adults. However, some experiments have shown that there is a well defined optimal speech-playback interval for adults, and it has quite recently been shown that the optimal interval for children is appreciably longer. If there is a lengthier delay, children are quite susceptible to delayed auditory feedback. The delay obtained in this procedure was obtained by a simple alteration of a Tandberg tape recorder, an instrument often used in delayed feedback experiments, but it did not take into account differences that have recently become known in the intervals to which children are sensitive.

The preceding pages have described, procedure by procedure, a battery of 13 tests developed to achieve a sampling of the reported changes in the 5-7 age range. Representative data for American schoolchildren have been given using the data from our last Brookline sample. This battery was the one used by Super for his study of African schooled and unschooled children, and it was used for a study of transition classes in Weston, also to be described. Enough indication has been given about theoretical expectations and interpretations from data to indicate the present status of this system of testing. A few general conclusions offered from the series of cross-sectional ventures will be offered below.

1. The massing of procedures into a testing procedure such as this one approximates a straightforward psychometric procedure. It is much like the rather well-developed process of assembling something like an intelligence test or a school readiness test. The studies did not have the intentions or the scale of a test development project yet, for better or for worse, a great deal of the work involved issues much like those encountered in psychometric work. Generally, tests bring together items that are somewhat less rationalized and that are somewhat less connected to known theoretical issues than was the case with this set of items. Undoubtedly, it would someday be ideal to be able to make up a testing or assessment procedure with content whose aims and purposes are known and understood in a theoretical sense. Yet, in the present state of the art, this kind of treatment of pooled items seems to stand midway between research and psychometry, not really satisfactory in either sense.

2. One intention of the effort, to seek replications of a number of literature findings, was satisfactorily carried through. A very high percentage of previously reported findings was sustained in re-examination. However, 'replication' seems somewhat too straightforward a term for the kinds of confirmations that generally seemed to obtain. There are a few phenomena of transition in the 5-7 age period that have been pursued in an analytic research literature; American reports of transposition and reversal-nonreversal shifts, and Piagetian reports of the attainment of conservations, are conspicuous examples. It has been the case that these

subsequent literatures have usually led to considerable qualification and reinterpretation of the original findings as originally interpreted. In this work, the repetitions of previous procedures almost never yielded pat replications. Rather, they yielded data suggesting the beginnings of modifications or elaborations of findings originally reported as relatively simple.

3. Viewing the transitions originally as relatively simple, an original intention had been to attempt an informal kind of cluster analysis, separating relatively early from relatively late changes, and seeking in other ways to try to find out which transitions tend to come together and separately in time. However, the experience of development of the battery to this extent tended to discourage optimism about this. First, it rarely seemed that the observed transitions were simple, as noted just above. They rarely seemed to reflect one process or one acquisition. Second, informal experience gathered in the development of instructions and testing procedures and scoring suggested that questions of whether a child manifests a competence earlier and later is quite relative to manipulable "performance" conditions. It happens through chance and through luck, that some competences can be assessed using procedures that are relatively clean, without elaborate instructions and paraphernalia, and thus relatively easy to follow for children. Generally, such competences tend to be found earlier. But it is not clear that such competences develop earlier. One may simply be able to establish a simpler game with which to draw them forward.

4. Again and again the issue of cooperation with procedure appeared in this work, in both gross and subtle senses. The informal experience gathered here suggested that there were significant complexities involved when one seeks to involve a child in a rule game over extended periods of real time and that a kind of "g factor" governing the body of 5-7 transitions is the question of how much and to what extent in time the child can play an experimenter's game and thus demonstrate a competence to the experimenter's criterion. In a number of cases, we had difficulty establishing instructions so that all children could meaningfully execute the task. The question of cooperation with procedure was raised in White (1970), and this question was an important basis of the analysis of attention span to be offered below.

Studies of the Coincidence of Change in Children: An African Study

During the course of the testing program in the Brookline schools, it became likely that we would have an opportunity to see an extension of the work in another culture. Charles Super, then a graduate student at Harvard, had received funds from the Comparative International Program of the Department of Social Relations at Harvard for the purpose of examining transitions in the 5-7 age range among African children. From the point at which this opportunity presented itself, Super worked with the Brookline program in the development and testing of procedures. He was concerned

to familiarize himself with the testing. It seemed desirable that he become as familiar as possible with the behaviors of children in reaction to the series of procedures because it seemed certain that such familiarity would be helpful in the difficult process of translating tests into use with children of another culture.

Super negotiated with several ongoing field sites in Africa about possible cooperation with this program. He was fortunate, we believe, in that he finally worked out an arrangement with Dr. Alastair Heron in Zambia. At that time, Dr. Heron was director of the Human Development Research Unit, Institute for Social Research, University of Zambia. It was to this research unit that Super went and, with what must have been splendid cooperation, achieved a good-sized African study using the Brookline battery of procedures.

A detailed report of the African research is given in Appendix A. At this writing, a revised version of this report has been prepared and that revised version, formally submitted to Zambia under Super's agreement with them, is in circulation as an H.D.R.U. (Human Development Research Unit) Research Report.

In the African study, the battery of 13 cognitive tasks was administered to two samples. One was an urban sample of 192 individuals drawn from a residential area of Lusaka. This group seems to represent an African counterpart of the typical sample of children usually drawn upon for research in the more developed societies, in the sense that it was urban and schooled. The children were living in a city with only remnants of tribal identification and culture. Beginning at seven the children went to school. Their age placements in school were less regular than in American schools and, probably, their curriculum in school differed. Super's other sample was drawn from two rural villages some 300 miles from Lusaka, both of them villages of mud huts with straw roofs. They are villages of the Chewa tribe and in both villages traditional patterns have just begun to give way to a current drive to create a developed Zambia. However, despite a national drive to create universal literacy, schools have only recently been established in the two villages and as yet only a few children go to them. From these two villages, Super drew a sample of 94 subjects with no exposure to Western schooling. The subjects in these two African samples ranged in age from 4 to about 50 years of age. As many subjects as possible were obtained in the age range corresponding to the American sampling but then, to follow up on developmental trends in later years, the subject pool was augmented with older individuals.

The African study was undertaken in an effort to examine the existence of developmental discontinuities in the 5-7 age range in a different cultural milieu and among children who are not exposed to schooling. A detailed discussion of the African findings is to be found in Super's report given in Appendix A. The report includes figures picturing African urban and rural data on the measures discussed above for the Brookline sample. The major conclusions reached in the African study were these:

1) Children under 6 were less able than older children to function adequately in standard kinds of experimental-testing conditions. This was relatively pronounced for the African sample, but this seemed to be true in more subtle ways for American children who are ostensibly more able and willing to cooperate with the formal demands of testing procedures.

2) During the 5-7 age range there is marked improvement in the tests that seemed indicative of the ability to perform visual analysis and integration.

3) During the 5-7 age range, the ability to perceive and use certain kinds of nearly simultaneous sensations emerges.

4) Evidence was obtained for rapid growth in the kinds of indices of cognitive maturity studied by Piaget.

5) Enough modifications of procedure had to be made to make it impossible to regard the African study as an exact cross-cultural replication of the Brookline study. However, rough cross-comparisons suggest that the age trends observed in the American and African urban sample were quite similar, with some tendencies towards lags or differences in performance in the African rural sample.

Weston "transition class" Study

An opportunity came to use the testing procedures used previously in Brookline and Africa for examination of a special class of American schoolchildren. Weston, an upper-middle class suburb of Boston, had created a transition class for kindergarten children judged to be "relatively immature" by teachers and therefore at some risk if placed in a conventional first-grade class and judged by first grade standards.

The definition of "relatively immature" offered by the Placement Study Committee creating the transition class arrangement is of some interest.

"This notion (that of relative immaturity) is conceived in terms of acclimation to academic situations and is extremely difficult to define in behavioral terms. The behaviors in mind are characterized by descriptions such as short attention span, lack of persistence, high distractibility, discordant silliness, and high dependency. The maturational notion about the underlying causes of these behaviors is distinct from notions about the causes of possibly similar behaviors which are related to intellectual deficiency, social-emotional problems, or the perdurable hyperactive nature of a child. In other words, the behaviors in mind are seen as age-related phenomena which are dysfunctional or inappropriate

in the context of certain first grade situations. These phenomena must be treated differently from behaviors caused by other problems."

It was, probably, this statement that teachers in Weston used as a basis for their selection of 16 children into a transition class. Using the battery of testing procedures previously used in Brookline and Africa, we tested these children. Each child was paired with a control child in regular first grade placement. Each transition class child was matched for sex and chronological age by a regular class child. The 16 controls so arrived at were also tested.

Comparisons of the transition and regular class samples were distinctly encouraging, in that they revealed a bit of data upon the teacher's judgments. The data points obtained in this study are pictured in Figures 1-21 above, juxtaposed on the age trends observed in the Brookline sample. Filled points are for the regular class children, empty points for the transition group. These figures reveal a regular tendency for the transition group to give a "younger" mean response than their regular-class counterparts. About half of the obtained differences were statistically significant differences. An effort was made to embody the body of data in a formal discriminant analysis, but results were difficult to interpret. There were more measures than subjects and there could be no real meaning to the discriminant analysis unless one had four or five times the available supply of transition class children.

Limitations of subject availability and time made it impossible to extend the transition-class comparison. However, it seems distinctly likely that an extended study with much larger N's would reveal that it is feasible to develop an objective procedure that would predict teacher's judgments of relative immaturity. Whether such effort would lead to a useful instrument capable of objectifying teachers' judgments and/or predicting first-grade adjustment is uncertain. One might simply be reinventing the school readiness test, not one of the most successful or highly regarded psychometric instruments. However, this approach to readiness testing encompassed items whose psychological and theoretical meaning had been explored and about which there was some understanding. However, a considerable amount of background and basic research would have to be undertaken with these and other like procedures before one could arrive at a rationalized predictive instrument.

Note that an important feature of both the Weston criteria and the procedures, is the self-conscious direction of interest away from issues of purely intellectual and cognitive competence and towards issues of attention, persistence, cooperation, and dependency. It is likely that the central issues of school readiness can now be addressed across a broader spectrum of developmental issues, and this is manifest in both current school practice and the present trend in developmental studies of children.

Developmental Changes in the 5-7 Age Range: An Overview

At this point, we bring together the results of the several analyses previously discussed to try to give an overview of the developmental changes in the 5-7 age range. This overview is useful in that it will allow description of the implications of the several analyses for an understanding of what is meant by "readiness" for schooling. It is introduced at this point in the discussion, because it was the influence of this kind of reasoning that led to the specific studies to be discussed in later sections of the report. We were led by ongoing consideration of the 5-7 material to frame particular kinds of experimental approaches to questions of the developmental organization of attention and cognition.

On the whole, it has seemed more and more likely that the body of psychological or behavioral data about developmental change in the 5-7 age range can only be understood with a parallel consideration of psychobiological data on the one side and social and cross-cultural data on the other. The behavioral data, as we now know them, may reasonably be suspected to express forces or agencies that go beyond traditional psychological models of learning. They express maturation. They express social "stagings" of childhood -- that is, the tendency of human societies to require that children as they grow perform in new contexts, satisfy new rules or constraints, or meet new expectations.

1. There appears to be reasonable evidence to support the belief that a maturational component underlies a good many of the observed behavior changes. Evidence for a "mid-growth spurt" in the growth of the general bodily dimensions of the child is still, at best, shaky. But there are diverse signs of brain maturation at loci that would appear to be strategic for certain kinds of counterpart behavior changes observed at this time. There are apparent changes in children's vulnerability or susceptibility to treatment for certain kinds of mental or neurological disorders. Some of the behavioral indices that change one way in the 5-7 age range seem to change back in old age. All this suggests that something other than experience or learning is involved in the behavior changes in childhood.

2. The nature or loci of the maturational changes is a matter of extreme interest. Unfortunately, our present understanding of the growth of the child's brain is limited, as is our present understanding of changes in the child's physiology -- particularly, the kinds of biochemical and endocrine changes that might be most useful in understanding psychological changes. One can suspect that changes in the parietal lobe's functioning must be involved. There are morphological signs of a full maturing at this time, a completion of myelinization in the parietal lobes. Some of the behavioral indices that are reliably observed to change in children at this time -- the face-hand test, right-left discrimination, Bender-Gestalt test performance -- have been specifically identified as degraded in adults with

parietal lobe damage. One might suspect that children before the transition do poorly on these tests because of imperfect parietal lobe function and that older children do better on the tests because of the maturing of the parietal lobe. A number of other poor performances of children before the transition seem to resemble poor performances of parietal patients. That is, they look like "constructional apraxias." Finally, one must note that there has been a persistent argument for a linkage between parietal lobe symptomatology and certain types of reading disability in the early grades of school.

3. It seems reasonable to believe that there are other sites of maturation that must have an influence on changes in children's behavior in this age range. There are indications in the literature of maturational changes in 5-7 children in (1) corpus callosum, (2) hippocampus, (3) cortical association areas coordinating parietal, occipital, and temporal lobe activity; and (4) possibly, several kinds of endocrine function. With the exception of the data on endocrine changes -- which seem weakest, most fragmentary, and most confusing -- each of the other reported sites of maturation could be assigned a plausible behavioral interpretation on the basis of known neurophychological data. The myelinization of the corpus callosum would provide for a coordination of right and left lobe function and this could be a likely basis for the coordination of "language" and "thought" attributed to the 5-7 age range by both American and Soviet theorists. The child would be "split-brained" before the transition. Maturation of the hippocampus could account for a reduction of playful, emotional socioaffective characteristics -- a reduction in "childishness." Maturation of cortical association areas could account for a number of findings commonly held to be suggestive of "intersensory coordination" or "cognitive decentration" at this time.

4. Such maturational changes, as they become better known, would imply more and more clearly the substrate or boundary conditions governing behavior changes that occur, or that one might expect to be trainable, in the 5-7 age range. But another set of boundary conditions needs to be considered, and this set has to do with changes in the child and in his society with regard to their understanding and expectations of each other.

5. The data of Super, and other similar cross-cultural data, now make it plausible to assume that a significant number of basic cognitive changes may be observable in children of widely diverse cultures. The evidence seems to indicate that a majority of the tests of change survived the transition from suburban, schooled America to rural, unschooled Africa. It might be expected that maturational changes in the development of children would be basis for the expectations of all cultures about children, would stimulate some kinds of cultural expectations and would constrain others.

6. There is reason to believe that many and diverse cultures make the attribution of heightened maturity and responsibility to children in the 5-7 age range. Data reported in White (1968) suggested, quite tentatively, a cross-cultural tendency of this sort. As this report is

being written, a more elaborate and careful exploration of the cross-cultural files is being undertaken by Nathan Fox, Sergio Pirotta, Barbara Rogoff, and Marta Sellars, a group of graduate students at Harvard. Their preliminary data, taking in a larger sample than the original analysis and using a more stringent rating system, show a clear clustering of indices of social expectations of responsibility in the 5-7 age range. One might expect that Western and American practices -- the Common law and Canon law attributions of moral responsibility at 7, the placement of the child in school at 5 or 6 -- represent one instance of a cross-cultural tendency to institutionalize new responsibilities from children at this time.

7. There is not a full admission to society, or a full attribution of responsibility, anywhere. One suspects that the child is admitted into an apprentice membership into society. This would imply that he passes from what Talcot Parsons would call "particularistic" institutions for cooperation into expected "universalistic" cooperative institutions. He leaves the family and must deal with strangers. Cooperation with strangers is rule-governed and involves participation in gamelike formal arrangements, that is, systems in which the participation between people is embodied in formal arrangements. It seems significant in this regard that this is the age range to which Piaget assigns the first real ability of the child to play rule games.

8. One might believe that the "stage" change attributed to the 5-7 age range is largely a social stage change -- that is, a marked transition that is more analogous to the event of graduation than the event of adolescence. While there are numerous small signs of significant physical growth, what may be most marked about this age range is that societies capitalize on an aggregate of small changes in the behavior engineering or operating characteristics of children to place the child into a social apprenticeship. This would seem to argue that the diverse maturational and information-processing and cognitive changes add up to some pattern that is socially functional in some new way.

9. What may be socially functional is the following: (1) the ability to calculate in consensual models of reality (space, time, and causality); (2) the ability to understand consensual models of society ("contractual dependence"); (3) the ability to productively 'socialize' his thought by dialogue; and (4) the ability to organize his behavior in cooperative rule-governed social systems in which strangers interact with one another. All these require more analysis than can be given in this summary statement. By (1), it is implied that a great deal of the "cognitive development" set forth by Piaget is at heart a kind of social development, as well. The child in his acquisition of the various conservations is not learning about the orderliness of the physical world; he is coming into agreement with the nominalizations and dimensionalizations of his cultural group about space, time, number, etc. By (2) it is implied that parallel to this is the acceptance of conventional social dimensionalizations of people and groups in society. By (3) it is implied what Piaget and others have asserted as central to the dynamics of this age range, an ability to engage in productive dialogue with others, to

socialize thought, to take the role of the other in cognition. Following the full logic of Piaget's analysis, this must imply the beginnings of an organization of self- and other- concepts along conventional social dimensionalizations. A recent qualifying paper done at Harvard reviews much evidence for the child's increasing accuracy and adequacy of social judgment in the 5-8 age range (Pratt, 1973). But, by the very nature of the issues, questions of the accuracy or adequacy of the child's social judgment must be seen as irresistably boiling down to questions of their consensual validity. Finally, point (4) above, the notion of the child's developing ability to engage in cooperative rule-governed social systems, turns us to subsidiary analyses and questions of attention and learning.

The Construction and Defense of Attention Span

One of the most fundamental issues in the consideration of changes in the 5-7 age range is the issue of what we have so far loosely called that of "cooperation with procedure." This issue seems more and more central as one considers the body of research data. Indeed, the issue seems so large that one might consider at once the central problem concerning the meaningfulness of the findings in this age range and, at the same time, a central finding about the age range.

Put very simply, the problem is this. Preschool children are notoriously poor at operating in experimental or testing situations. One has to be very careful in trying to work with them but even so they get easily confused and when they do they may not realize it or they are very likely not to let the experimenter know. They muddle through, showing behavior that is functionally somewhat random. (It is not random in the real sense of the term, but from the point of view of the choices posed in the test or experiment it often is.) The problem, in view of this, is how to interpret findings obtained when tests or experiments with preschool children are compared with the same tests or experiments with older children. This is almost always the case with data relevant to the 5-7 transitions -- not always, because some data do not raise the issue of cooperation with procedure.

The test that one must always apply to new findings is a kind of test of parsimony. Often a new finding claims some specific inability in younger children -- younger children do not reason, form concepts, perceive wholes, etc. In order to evaluate the claim, one must mentally try to think through the procedure as portrayed in the paper...ask whether the experimenter seems sensitive to the issue and has taken precautions and if, even so, one might have obtained the given results through simple inefficiency and randomness of behavior on the part of the younger children. There is an analogous problem in experiments designed to get at deficiencies of schizophrenic thought. Possibly, one of the sources for the persisting argument that schizophrenic thought is "regressive" towards childhood thought is the fact that both schizophrenics and children tend to behave inefficiently and somewhat randomly in tests and experiments. But when the grossly similar deficits of schizophrenics and children are examined

more closely and carefully, one often finds that schizophrenics are making one kind of mistake and children another (Grim, 1965). To avoid confusion, it seems necessary to test findings of specific inabilities in young children against a hypothesis that they derive from inefficiency, and to suspend judgment about any assertion of a specific disability of younger children if inefficiency or noncooperation would seem to explain the finding.

It would be nice if a sophisticated reading of research papers could always cope with this problem. But the problem may be hidden. The issue is not only a question about whether an experimenter is sensitive to and knowledgeable about children. There have been repeated cases in the research literature in which experimenters equally adept in working with children have come into differences of opinion about the nature or the age-placement of developmental changes. To give one example out of a number that are possible, some years ago Lipsitt and Serunian (1963) published an article that seemed to demonstrate that children could not solve oddity problems until they reached seven or eight years of age. The article was reasonably convincing and, since it was consistent with some Piagetian arguments about the development of concrete operations, might have been accepted. But Levin and Hamermesh (1967), curious about this finding, ran a series of groups for whom testing procedure was systematically varied and produced lower and lower age of solution with progressive simplifications of the procedure. They argue:

> "The implication is that in many laboratory studies the essential learning has been the discovery of the game that E was playing."

The central problem with findings concerning 5-7 changes seems to be this: we do not know how to interpret wholesale reports of perceptual, cognitive, linguistic, and other changes in children at this time because we may suspect any or all of the reports to reflect a generic improvement in children's ability to cope with standard tests and procedures.

But, at the same time, the most central finding about the age range may be this very decision about the artifact -- that is, that children suddenly become much better in playing the games that testers and experimenters play with them. We do not have a sudden blooming of a ramified set of new competences. We have the appearance of a performance capability through which, suddenly, a range of competences are made manifest.

We need to ask what this performance capability might be, and a reasonable way to examine this is to inquire into some well-known issues in testing preschool children.

Special Characteristics of Procedures for Young Children

There is an art in setting up experiments for young children, not wholly given in the art of testing older children or adults. Most psychologists are familiar with the general limits or constraints that apply to experiments with human adults, either because they have experience with such experiments or because, being adults themselves, they can readily and easily empathize with what adults can handle. They know naturally how long and how complicated the instructions can be, how much they can ask of the subject without producing fatigue or boredom, what motivates adults, what their manipulative capabilities are, etc.

For many psychologists, there must be a self-conscious adjustment of approach when they address themselves to preschool children. Preschool children have special and at times surprising limitations. It seems possible that if we consider these limitations we will begin to identify some of the generic issues involved in children's game playing. The discussion here follows that in White (1970). Generally, one must take the following kinds of special precautions when attempting to engage very young children in experiments:

--One must spend some effort in the prior creation of "rapport" with young children. Preschool children, particularly the younger ones, are shy with strangers and so one spends time to establish a familiar and friendly status. The issue of liking and warmth is important in eliciting entry into an experiment in the first place and then in keeping continuation. Young children seem to stay in experiments because of experimenter approval and, indeed, the experimenter must be extremely careful not to become a significant distractor. The children will try to watch his face and do what he seems to want them to do as opposed to playing the game. The child's success or failure on the task is often defined largely by the way the experimenter reacts, not by objective performance. By the time of the early school years, this has visibly changed. Children will readily deal with strangers. They are aware of what the demands of the game are. They test their competence against those demands and will often react negatively if the experimenter tries to "kid" them -- give approval when plainly they are doing badly.

--One arranges as simple a visual and auditory environment as possible. One tries to keep out distractors. One tries to make the physical loci of attention and action -- the stimulus windows, the response targets -- as salient as possible and, usually, as close together in space as possible. As one gets experience with a test or experiment, one tends to intuitively seek a right pace and right rhythm -- not too fast, not too slow, not too regular, not too irregular -- and things seem to go better after this is settled. There are more favorable arrangements of the procedure in terms of spatial and temporal organization. Until one finds them, one tends to sense that the child is disrupted or distracted.

--One never gives a young child lenghty verbal instructions. The shorter and briefer the verbal instructions the better. One leads the

child's attention and action by gesture. One points to the cues. Instructions are usually mixed with actual motor rehearsal of the moves the child will later make in the course of the procedure.

--When he begins the procedure, the experimenter usually takes pains to conspicuously "notice" the first few times the child behaves correctly. The experimenter says, "Good!" or praises the child. He does this because he is not completely sure the child knows what he is supposed to do, and this noticing is intended to supplement the instructions.

--Periodically throughout the task, one tends to repeat to the child a sentence or a phrase that recalls his goal to him. One does this because one is always a little uncertain about the maintenance of the child's plan over time and one wants to refresh the plan.

The above are the major kinds of procedural safeguards that are typically taken in work with young children. Consider what these precautions imply:

1. They imply that younger children have more difficulty in working with strangers. In terms of the analysis of learning proposed in White and Fishbein (1972), one important consequence of this would be that they might be expected to show more interspersed episodes of social regulatory behavior in the course of time. White and Fishbein propose a scheme in which episodes of cognitive, social, and mood-tension regulatory activities "time share" in the elaboration of behavior in real time.

2. They imply that younger children are more distractible and that they have more difficulty learning in noisy situations.

3. They imply that younger children have more difficulty sustaining a plan, or some significant aspect of a plan, over time.

Such performance difficulties of younger children may be regarded as closely associated with what has traditionally been viewed as problems of "attention span." Children have difficulty doing the "same thing" over time. This is not simply an issue in what is sometimes called the maintenance of attention or the maintenance of set. Almost all tasks that extend past one or two seconds in time require something more than a fixed gaze or a fixed focus. They require strategic direction and redirection of orientation, shifts from episodes of predominantly visual activity to predominantly motor activity, etc. Furthermore, because no environment is so pure that it is completely free of intermittent distractor cues, they require periodic reconstitution of an ongoing plan of behavior after interruption. One must regard "attention span"...sustained task activity... as a system of behavior that is constructed and defended in order to have an integrity over time.

The experiments to be described in the sections that follow were directed for the most part at issues of attention span and development as

outlined in the discussion just preceding. They were designed to extend this kind of analysis of the issues of development of performance capability or attention span.

Quasi-neurological Indices and Conservation

One set of studies undertaken by Gunnoe (1970) was undertaken in an effort to explore more sensitively the possibility of a relationship between neurological development and cognitive change in the 5-7 age range. The paper by Gunnoe describing the research is given in Appendix A and the findings will be briefly noted here.

Gunnoe examined two groups of first grade children, one drawn from Weston, an upper-middle class suburb of Boston, and the other drawn from a lower or lower-middle class area of Cambridge. He gave both groups two sets of tests, one directed at neurological status and the other directed at attainment of several of the Piagetian conservations.

The neurological set consisted of two parts, one part the set of three Bender-Gestalt items previously used in the research reported above (the Brookline-Africa-Weston series) and the other a set of tests of associated movements. The Bender-Gestalt tests requires that the child reproduce drawings that are shown to him, and the drawings the child makes are scored for omissions, rotations, and distortions. The tests of associated movements ostensibly involved a rather different issue. In these tests, the child was asked to execute a moderately difficult motor movement and scoring was made if there were "echo" movements elsewhere in the body. In four of the five tests, the child was asked to execute something with one hand and an associated movement might occur in the other, noninvolved hand. In the fifth test, the child was asked to walk in an awkward way and an associated movement was scored if the hands conformed.

Errors on the Bender-Gestalt test tend to decrease markedly after 5 or 6, as has been noted above. Associated movements are known to decrease with age as children grow older, although there is no marked 5-7 transition in their decline. Both the Bender-Gestalt performance and the associated movements tests were considered to be "quasi-neurological" because of their history of use in neurological diagnosis. They are among the battery of behavior tests used by clinical neurologists in attempting to diagnose dysfunction of higher cortical centers. Negative signs on such tests in children, of course, could not be considered evidence of brain damage or abnormal status. But there is an argument to be made that they might be indicative of normative processes of cortical organization during the course of postnatal neural development. Indeed, such associated movements have been used in the literature of pediatric neurology, considered as an index of the development of cerebral inhibitory systems or, more grossly, as an index of neurological maturity.

Gunnoe's Piagetian set consisted of three of the typical situational tests. He gave the children what have by now become fairly standard testing routines for conservation of substance, conservation of number, and

cross-classification. For each test, the child's responses were used to classify him as a Nonconserver, Transitional, or Conserver.

Numerical values were assigned to performance on both the neurological and conservation sets of tests. Generally, Gunnoe's studies found evidence for an association between the scores obtained in the two sets of tests. Children who made fewer distortions in Bender-Gestalt drawings and who showed fewer associated movements tended to show more conservation on the Piagetian tasks.

For the Weston sample, the correlation between the neurological and the conservation tasks, with age partialled out was .56, with IQ partialled out, .57. For the Cambridge sample, the equivalent correlations were .74 and .69. The Cambridge sample showed more negative signs on the neurological tests and less conservation than the Weston group. Probably, the higher correlations for the Cambridge study might be explained by less restriction of range, a broader spread of scores on both neurological and conservation instruments, than was obtained in Weston.

Subsequent studies revisited the two groups to obtain some indication of the reliability and stability of the measures. The neurological tests were re-administered to 28 of the Cambridge sample between 9-35 days after first-testing. The test-retest correlation was .75. This might suggest that the neurology-conservation correlation was about as high as the reliability of the neurological assessment would permit.

Between 109-136 days (about four months) after first testing, there was a complete retesting of 28 of the Weston sample, both neurological and conservation testings. There had been measurable improvement in both kinds of test scores over the four-month interval. The correlation now between neurological and conservation measures, age and IQ partialled out, amounted to .42. This shrinking of the Weston correlation over time might have been due to a further truncation of range over time.

The possibility raised by Gunnoe's studies is of some interest, and lies in a direction that has so far been little explored. There have been few attempts to cross-link specific cognitive and neurological changes with age. Although there is by now a large literature on American testings of Piagetian hypotheses about the development of the conservations, most of the literature has been concerned with the thrust of the central theoretical assertions offered by Piaget. The literature has been directed at assessing the value of structural or stage arguments as explanations for the change. Piaget has made it abundantly clear that he believes maturation is at work in promoting children's cognitive development, equally clear that he does not regard maturation as a sufficient explanation, but he has never experimentally explored the influence of maturation. Gunnoe's analysis seemingly takes out the possibility that the connections between developing neurological and conservational indices can be ascribed to coincidences of age or IQ. It suggests that there may be a maturational substrate to performance on the conservation tasks.

The neurological tests given in Gunnoe's procedure have a history of association with problems of performance in school, ascribed to "minimal brain damage," "hyperactivity," "impulsivity," "poor attention span," etc. We do not know yet how much of the basic substance of cognitive development one can assign to such performance factors, as opposed to competence or structural factors. This question needs to be addressed, not only with respect to the Piagetian cognitive developments but with respect to the range of cognitive factors.

Studies of the Development of a Problem-Solving "State"

There have been repeated indications in the literature that human adults faced with a formal test or problem may successfully establish a special problem-solving state, marked off by distinguishing psychophysiological characteristics. The objective indices of such a state might correspond to what we feel and speak of as concentration on a task. There is a respectable and interesting literature relevant to this with adults used as subjects, but only one or two papers on children. Children are difficult subjects to use for psychophysiological studies and this probably best explains the shortage of data about them. However, one study done with children was suggestive and we therefore developed a series of studies in which some procedures were developed with adults and were then used with children in a study of development. Papers describing this research in some detail are given in Appendix A (Elias and White, 1969; Elias, 1970, 1971) and it will be briefly described here.

The studies were concerned with rule induction, with problems offered in a trial by trial format. Early in the series, discrete problems were given one by one. Subjects were given pairs of item, choosing the right or the left item by signalling on one or another response button. Each time, after choosing, the item that should have been correct was signalled to them. Then a new pair of items was given; they chose; a signal was given again. Subjects solved a series of items by recognizing a principle -- word meaning a liquid, number that is a multiple of three, capital letter containing an acute angle. When they recognized the principle, they could and did choose directly every time.

In an experimental format like this, one could reasonably study "off" events -- that is, psychophysiological events suggesting that the rule had been generated and the problem solved. This was done experimentally by analyzing psychophysiological response characteristics before and after the point of solution -- specifically, on trials before the first trial of a criterial series versus trials after the first criterial trial. One assumes that when a subject enters into a run of trials without errors that he has grasped the rule and that what follows during criterion is mechanical and does not really involve effort with the problem. In addition, some problems given the subjects went on and on without any solution. The subject did not give an errorless run nor did he indicate solution upon inquiry.

The trials of the induction problems were given with accompanying psychophysiological recordings. For each trial, skin potential, finger vasoconstriction, and response latency were recorded. Early work with high school students indicated that the skin potential and response latency measures at least, and possibly the vasoconstriction index, showed early-to-late changes suggested that they tended to decrease after problems were solved. This kind of finding, suggestive of a lowering of orienting excitation after problem solving, was consistent with a considerable amount of previous research (Germana, 1968).

A problem with this design, however, was its unsuitability for the study of the recognition or initiation of problems. As in most studies of problem-solving, the organization of the procedure confounded the first trial of each problem with starting events and with the offering of novel stimuli. Each problem was run through with its set of slides. Then, when the problem was completed, there was a pause and the slide projector was reloaded, arrangements given a quick check, and a new set of trials begun. The events of starting are generally reflected in psychophysiological measures. Subjects take a few trials to "settle down." If one wanted to study "on" events, psychophysiological indices of the recognition of a problem to be solved, such recognition had to be dissociated from starting.

A procedure was devised in which series of rule induction problems were used. One problem built on the next one. The subject would have to induce the rule 'even number' and then, having done so, he would be faced with a pair of even numbers to begin work towards the rule 'two-digit even number,' etc. The procedure ran smoothly along from one problem into the next.

High school students were used for this research and, again, psychophysiological measures were taken concomitantly. Since vasoconstriction indices had not worked well, heart rate measures were substituted, so that trial-by-trial measures were taken of skin potential, response latency, and heart rate. In this study, both "on" events and "off" events were found on skin potential and response latency measures, although heart rate measures appeared insensitive to either the beginnings or the endings of problems (Elias, 1970). It was argued that the recognition of the problem by the subjects instigated a "labile period" that persisted until the recognition of the solution of the problem.

In the final research of this series, the procedure developed above was modified for use with children. The major modification lay in constructing new series of rule induction problems that were appropriate for younger children. Children were drawn from a Cambridge school in a working-class neighborhood, 16 children from each of Kindergarten (age 5-6), Second grade (age 7-8), and Fourth grade (age 9-11).

Elias's expectation, based on interpretation of a few pieces of previous research, was that the labile state previously identified among high school seniors might be forming in the age range sampled in the study.

Accordingly, the design and primary analysis of the research with the three age groups corresponded to that previously executed with the high school group, but the central issue of the study rested on secondary analyses in which age comparisons were undertaken.

Elias provides the best summary of her own research:

"To summarize what has been found: A labile period was found in 9-year-olds which continued from recognition to solution of a problem. In 7-year-olds it was present but erratic, but in some measures more evident for the skillful solvers. In 5-year-olds there was a momentary surge of response at recognition of a problem but lability did not continue until solution. These results appeared in both the latency and skin potential measures, more strongly in latency.

"Cognitive hypotheses were put forward which are supported by the findings outlined above. First, the 5-year-olds were found to stop processing the problems almost immediately which meant that if they didn't solve at once they were unable to solve at all. This inference can be related to the rather vague notion of attention span, but these data do not distinguish between a stop rule determined by elapsed time and one determined by number of hypotheses tested by the child. The concept of attention span seems to imply that the limiting factor is time. The limit could be set instead by number of cognitive units which can be processed. The nature of the stop rule would be an intriguing subject for further research.

"Secondly, it was postulated that the 5-year-olds were engaged in a different enterprise from that of the older children although all had been given the same instructions and the same task. The younger children's notion of the task seemed to be to respond to each picture. They organized the pictures into problems only briefly and sporadically. Other unrelated organizations of the task were satisfactory to them. Their cognitive processing was inferred to involve solution of problems such as 'How can I please the lady?' and 'What game can I make out of this which will please me?' rather than the problem which was set by the instructions. The organization of information implied by five-year-olds' performance was interpreted as due to processing of trials in a linear sequence with loose connections. It was suggested that a shift of developmental stage had occurred, or was in the process of transition, by age 7. The higher stage beginning at 7 and consolidated by age 9 involved processes of trials as instrumental to an overriding task of solving a problem. Operations were nested into a hierarchical organization so constructed that it could execute a number of operations on each trial and keep track of each over a series of trials."

(Elias, 1971, pp. 65-66)

The "labile state" identified as associated with the problem-solving of high school seniors in this research is in a curious way consistent

and inconsistent with previous research. The labile state is generally indicative of a kind of heightened excitability -- specifically, excitability to the signalling events of the problem format. The previous research that had led towards this line of research had similarly suggested a special problem-solving state, but the emphasis of the analyses had been towards the postulation of a state of lessened excitability, of heightened thresholds. This had been the emphasis of Kahneman's research on pupillary gradients during problem solving (Kahneman and Beatty, 1967), and of the series of studies done at the Montreal Neurological Institute on muscle-tension gradients during problem solving (Malmo, 1965). Perhaps what is fundamentally involved in the similarities and differences between these lines of research is a mechanism that John Lacey at Fels has suggested, a kind of tradeoff in direction of excitability. Our research and research of the kind reviewed by Germana (1968) has suggested a heightened excitability for problem-relevant events, while that of Kahneman and Malmo may reveal a compensating dampening of excitability for extra-problem events. In this connection, it is of some interest that work done in Malmo's laboratory (Elliott, 1964, 1966) suggests the development of muscle-tension gradients in children at about the same age range as that given by Elias for the full organization of the labile state.

Organization of Picture Sequences

The analyses of attention were concerned, in several ways, with factors that were suspected to mediate the temporal organization of the child's behavior. One issue, the classical issue of attention span, was the issue of how the child maintains or continually reconstitutes a plan of activity across real time until the plan is either completed or set aside deliberately. Gunnoe's analysis of neurological signs and conservation was based on the suspicion that the weakness of preoperational children in tasks like the Piaget conservation task or the Vygotsky concept sorting task might lie in the child's inability to maintain organized constructive activity over time. This was seen as akin to what neurologists call "constructional apraxia" or "amorphosynthesis." Elias's sequence of studies sought to find a sustained problem-solving state. The argument here was that adults might have available a psychophysiological mechanism that protected the integrity of a line of behavior over time, that allowed concentration and tended to provide barriers to distracting cues.

A second developmental issue of temporal organization might lie in the ability of the child to order a set of events experienced across time. Adults effortlessly perceive the connectedness of adjacent events across time. If an adult perceives at $time_1$ two short fat glasses equally filled with water, at $time_2$ the contents of one of the two glasses being transferred to a tall thin glass, and at $time_3$ a short fat glass with water at one level and a tall thin glass with water at another, he will integrate these three perceptions across time and assert conservation. Indeed, there is no other way for an adult to make the judgment of conservation in the basic Piaget situations except for a proper cross-connection of a series

of temporally ordered percepts. One hypothesis that might explain the inability of younger children to solve such problems might be that they do not remember the earlier percepts or, more likely, that they do not see as necessary and obvious the need to connect them with the present percept to make a judgment of it.

Almost all tasks of judgment and problem-solving require an integration of experiences or judgments across time. There are various reasons for suspecting that younger children have difficulty in moving thought across time in such tasks. If this suspicion is true, it could be one source of the poor attention span of younger children. Children do not maintain behavior over time because they tend more to experience events episodically, and do not easily recognize "plot lines" in naturally occurring sequences of events.

An attempt was made to study something analogous to naturally occurring temporal "plot synthesis" by using specially developed picture sequence cards analogous to those used in the Wechsler Picture Arrangement cards. Cards were drawn up to make picture sequences. They were of four kinds and could be Abstract or Narrative, Simple or Noisy. An Abstract set consisted of five cards picturing an orderly physical transformation -- an object getting larger, an abstract shape adding elements, one shape being sequentially deformed to make another, etc. In Simple Abstract sequences, the only change from one card to the next in a sequence came in the visual element or elements that were in the process of orderly change. In Simple Noisy sequences, extraneous abstract elements were added to the cards of a set. In Narrative Simple sequences, the drawings were of real objects and the sequencing of the cards were not derived from simple changes in the shape or components of the figures pictured on the cards. The card sequences pictured stories and had to be understood as narratives of human events across time. There was a sequence that extended from a picture of a baby to a picture of an old man. Another showed men building a house. Still another showed lumbermen driving into a forest, cutting down trees, and driving away with wood. Narrative Simple sequences contained just enough drawing to indicate a story line. Narrative Noisy sequences contained extraneous elements. For example, in the Noisy version of the lumbermen story, one frame shows a car driving by, another shows a fox looking at the men; neither the fox nor the car appeared elsewhere in the set.

In the use of the cards, the children were first given each pack of sequence cards and asked to arrange them so they tell a story. After the child had arranged the cards, he was asked to tell the story given by his arrangement of the cards. Two kinds of attempts were made to study the development of the ability of the children to sequence the cards, neither of them wholly successful.

A first attempt arose from arguments to the effect that the best way to explore children's understanding of problems was in a training rather than in a testing format. Accordingly, working in a rather intuitive and ad hoc fashion, we attempted to develop a procedure in which we first

administered a few sequences of cards to children to establish their performance level and then attempted to coach them towards better performance. The children were kindergarten through second grade schoolchildren in Arlington, Massachusetts. We were not able to convincingly develop training arranged in this way. The simplest way to characterize an approach to brief training in this way would be to say that it is inadequate. Children appeared to respond to the sequence task in an all-or-none fashion. They showed clear improvement with age in the age range being surveyed, but the improvement did not appear to be "interesting." Some younger children seemed totally confused by the request to sequence, and the brief coaching that was tried did not appear to influence this. Some younger children easily grasped the notion of sequencing, but tended to make procedural errors. A common and somewhat interesting error of the younger children was their refusal to disrupt card arrangements once laid down. They would be given a pack of cards and would pick up the first three cards and place them in correct sequence (thus indicating that they grasped the principle of sequencing). Then they would pick up a fourth card which should properly go in the midst of the set already placed, would hesitate, and finally place the card on one end or the other. The oldest children, the second graders, all grasped the sequencing principle and made only a few careless errors.

More difficult cards were drawn up for another kind of experiment, which was given in a testing format to first and third graders. There were 30 first-graders and 30 third-graders, with each child given trials with the four types of sequence cards. The expectation was that there would be an Age X Noise interaction in ability to deal with the sequencing of the cards. It was expected that the younger children would be more thrown off by noise than would the older children, confirming in another format the trend of previous results by Walk and Saltz (1965), White (1966), and Brown (1969). Results showed statistically significant tendencies for older children to do better than younger, for Narrative problems to be easier than Abstract, and for Simple problems to be easier than Noise problems. But the expected Age X Noise interaction did not appear.

Some qualitative analyses were undertaken of the stories that children routinely told after making each arrangement. There was no consistent relationship between children's ability to make a perfect arrangement and to give a reasonable account of the principle of sequencing. Some children gave imperfect arrangements of the cards, yet gave a completely adequate statement of what the sequence was about. Others made consistently perfect arrangements of the cards, yet gave consistently lengthy and confabulated narratives about the cards that consistently avoided the point or the issue of the sequencing. There were clearly story-telling "styles" among the children, rather strikingly diverse ones. There was a tendency for older children, more than younger, to respond to the Narrative Noisy picture sequences by trying to think of ingenious ways to incorporate the extraneous visual elements into their story lines. But on the whole it

seemed that the issue of telling a story about a set of sequence cards seemed to arise after the sequencing, and the story-telling was not obviously revealing about the mechanisms governing the sequencing.

This line of research did not develop in a way that seemed useful for the issues being addressed. The approach being taken to questions about children's temporal integration was indirect and it did not seem ultimately worthwhile to try to invent ways to use the sequence cards productively with regard to the issue.

Effects of Stimulus Noise on Performance

The failure to find an Age x Noise interaction in the previous line of research was a matter of some concern because, empirically and theoretically, the existence of age x noise interactions was taken for granted in the analysis of attention being undertaken in the project. That is, much of the project's design rested on an expectation that previously observed interactions of this sort, observed in repeated experiments, reflected a tendency that should be demonstrable in almost any problem format. Furthermore, both common expectations about children as well as several interesting lines of theoretical argument assume that younger children are more disturbed by distraction than are older children.

Several further experiments were undertaken to explore the effects of noise on the performance of children of younger and older age levels. These experiments are detailed in Appendix A (White and Mansfield, 1969; Mansfield, 1970) and their findings will be briefly described here.

A first approach was made by establishing an experiment which included a direct replication of a previous design in which, repeatedly, age x noise interactions had been observed. The replication sought for was not obtained (White and Mansfield, 1969). It is not clear why. Scientific logic should have dictated subsequent attempts to explore the nonreplication more extensively, to try to establish the basis on which one could or could not find the effect. This was not done. The major reason for this was that the principal investigator, at one point in his career, had once spent a year of time and the time of over 500 subjects in a repeated, fruitless pursuit of a finding that had seemed solidly established through replications in three different procedures.

A fresh approach was taken to the problem by developing a different format by which studies could be undertaken of the effects of noise on children's problem solving. A standard simultaneous discrimination format was modified to allow for the introduction of graded amounts of visual noise. The child began each problem with trials on which his choice cues, line drawings, were presented to him in a straightforward manner. Ten levels of visual noise were set up, by preparation of plastic overlays in which from 0 to 32 line-drawing shapes were randomly drawn on the field. At the lowest level of the series, the visual choice stimuli were being viewed through clear plastic. At the highest level of the series, the

visual stimuli were being viewed through a jumble of other figures. The serial set of more and more noisy overlays were used to arrange the trials in what approximated an ascending method of limits of psychophysical procedure. That is, each time the subject was correct an increment of noise was added. But, when the subject was incorrect, the next trial dropped back to the 0 level.

Thirty fifth-graders in Waltham were used in a first experiment with this technique. There were two kinds of visual discrimination problems, one with constant cues and one with evolving cues, pairs of line drawings that gradually changed shape from one trial to the next. Results showed that the children could sustain correct choices of a constant discrimination at the highest noise level of the series. But the evolving discrimination could not be sustained except at more moderate levels. There could be no question of the perceptibility of the discrimination figures amidst the noise; the uniformly high performance of the children in the constant discrimination indicated such perceptibility. What appeared to be true was that there was some sort of tradeoff between the 'perceptual' work involved in penetrating the noise and the 'cognitive' work involved in sustaining performance on the evolving discrimination (White and Mansfield, 1969).

In subsequent research, Mansfield (1970) attempted to study age differences in the handling of noise using a modification of this format. He used the kind of visual procedure indicated above, in which increments of visual noise could be added to visual discrimination problems of three degrees of difficulty. His results were reasonably in line with previous expectations, but this was true largely in terms of direction of effects rather than in the presence of statistically significant effects. More difficult problems were interfered with by noise more than simpler problems. Older children were less interfered with by noise than were younger children.

The study also included an auditory noise procedure in which the children had to detect spoken words through graded amplitudes of auditory noise, four voices speaking simultaneously. Thresholds for noise of the second graders were consistently higher than those of the kindergarten children.

The results of the several tests of the method of limits kind of procedure were generally positive, in the sense that the procedure yielded results consistent with expectations about age, problem difficulty, and noise. But the moderate size of these effects, plus the mixed positive and negative results existing in the previous work, led to the general conclusion that these kinds of procedures were not sufficiently efficient for the establishment of reliable findings about noise effects. Generally, all the procedures used had provided relatively few occasions for noise to have an influence and relatively insensitive performance measures for the ascertainment of an effect. If the effects of noise on performance are mild and intermittent, this would produce the weak-positive kinds of effects in the run of findings obtained in this and other research projects, but it would suggest that more efficient problem formats would be useful for a more intensive exploration of the issues.

More efficient problem formats would provide a higher density of "occasions" across time, and might provide for qualitative rather than categorical response evaluation. Automated, subject-paced tasks might provide the density of occasions. Parallel recordings of response latency or other intercurrent psychophysiological activity might allow for a more finely graded evaluation of the subject's response. The quantity of data all this would produce would require on-line computer data reduction. The technology for all this is readily available and has, in some signal-detection laboratories, been regularly used for work with adults. These laboratories are, in fact, the major sources for contemporary information about interactions of attention, noise, and cognitive processing. At present, optimal systems of data gathering have rarely been employed in work with children.

What has been gathered in the present effort and in related previous work appears to be relatively weak and unreliable evidence about some of the significant attentional issues. One can suspect, on present data, that children handle noise better as they get older (Gollin, 1960, 1961; Walk and Saltz, 1965; White, 1966; Turnure, 1967; Brown, 1969; Mansfield, 1970). One can suspect that, at any given age, there are tradeoffs between noise processing and problem processing, so that children might handle more complex problems under clearer conditions and less complex problems under noisy conditions (White and Mansfield, 1969; Mansfield, 1970).

Age Changes in Conceptual Control During a Word-Association Task

An important part of the general analysis of attention span governing the work of the project came through a consideration of the special environmental and procedural conditions that usually seem necessary in order to work on tests or games with children. This has been discussed earlier in this report and is discussed in White (1970). It seemed worthwhile to try to examine directly what is being managed when special procedures are devised for preschool children, and so an attempt was made to run a study in which there was somewhat relaxed control of the performance of preschoolers.

A standard experimental format in which differences are often revealed between preschool and older children is the word association format. There have been repeated reports of a "syntagmatic-paradigmatic" difference in the performances of younger versus older children; younger children tend to give words unrelated grammatically to the stimulus word, while older subjects tend to give noun for noun, adjective for adjective, etc. In another kind of analyses, the word associations of younger children have been scored as developmentally "primitive." As early as 1913, Kent and Rosanoff in establishing early children's norms for word association tests made note of the frequency of "idiosyncratic" word associations in the responses of preschool children. Over a long history, and in diverse ways, the data of word association tests have produced evidence suggesting

that the word associations -- and perhaps the associative processes -- are different in young children. The alternative possibility, which this sought to entertain, was that the attentional processes of younger children caused them to engage in the game of the word association task in a different way and, therefore, reflect different cognitive operations in that game. To put the question in another way, the issue was to what extent, and in what way, could 'performance' problems of younger children masquerade as 'competence' problems.

Groups of 20 nursery, first-grade, and third-grade children were compared in a uniform word association procedure. The procedure, by design, did not embody some of the precautions that are usually used in testing younger children but it proved impossible to do away with all. The major modification of the procedure seemed to be that, in general, it was designed to require that the child follow verbal instructions given at the beginning and repeated periodically rather than attempting to have him learn the task from training trials or through periodic corrective feedback.

Under these conditions, the procedure evoked markedly different responses at the different ages. Each child was given 30 stimulus words. Upon completion of the child's protocol, his list of responses was examined an attempt was made to assign a reasonable origin or source to each response. Some responses were scored as idiosyncratic either because they were multiple words or because they were responses generated by some apparent source other than a meaningful connection between stimulus and response words. Our data underestimate the tendency of the children to give multiple word responses. Because of the strong tendency of the children to give multiple word answers in pilot work, we inserted promptings against such answers into the procedure. The instructions emphasized one-word answers and subsequently, after the 5th, 10th, 15th, 20th, and 25th response, the experimenter said "Remember to tell me the <u>one word</u> that my word reminds you of." With these precautions the two scoring categories "Multiple Word Including Stimulus Word" and "Multiple Word Not Including Stimulus Word" accounted for 26.8% of the word associations of the nursery school children, 17.7% of the first graders' word associations, and 7.3% of the third graders' word associations. Other idiosyncratic scoring categories frequently encountered were "Repetition of Stimulus Word," "Perseveration Relating to Last Response." Responses not scorable as Idiosyncratic according to any of the 12 scoring categories were scored as "Clear" -- that is, as clear word associations. The nursery school children gave 17% Clear responses, the first graders 28%, and the third graders 85%.

The data obtained in this study were generally similar to those obtained typically in word association experiments with children, except that the yield of clear word associations was rather low for the two youngest groups of children. One interpretation that might be made of the pattern of the findings would be that the younger children could not understand or maintain the task of the experiment, and this is consistent with the interpretation of younger children's failings in many experiments, but this kind of interpretation would be somewhat inaccurate.

An inspection of what happened in this study, and what consistently tends to happen in many tests and experiments, is that two dissociable aspects of task cooperation emerged. One is maintained by the child and the other is not. The instructions of the experiment set forth a dyadic behavior routine and what Milgram and Furth have called a "conceptual control." The dyadic behavior routine is a rhythmic interchange pattern, you-say-something-and-then-I-say-something. The children maintained this easily in this experiment as, characteristically, they sustain the rhythmic interchange patterns of a large variety of experiments. It is possible that the generally rhythmic quality of the procedure sustains them; one notices that young children seem very sensitive to factors of pacing and regularity and smoothness in experimental procedure. It is possible, in addition, that the gesture patterns of the experimenter or the apparatus acts as a visible mnemonic for them. The "conceptual control" offered to the children -- that when they say something it is not just to be any old thing but it is to be that which the stumulus word reminds you of -- this conceptutl control was vulnerable.

The problem here, as in many experiments, was that children did not understand and/or maintain the conceptual control set forth in the instructions. There is an argument that the ability to use a conceptual control in a procedure such as this is a late-developing emergent in children, but an alternative argument might be that some conceptual controls are more costly than others. One might imagine that there are "high load" conceptual controls and "low load" conceptual controls.

If we look at the sequential responses of the children in the word association experiment an interesting pattern emerges. The children had odd systems for generating words. Some children repeated the stimulus words. A few children would count to generate their response words, saying "one" to the first stimulus word, "two" to the second, and so forth. More than one child adopted a look-around-the-room system, saying something like "door" to the first word, "wall" to the second, "window" to the third, etc. What seems to have happened was that the children uniformly understood that they were in a situation in which they had to periodically come up with words in order to play the game. Some could use the system offered by the experimenter to generate the words. Some could not, so they generated their own. One has to have some way to find words. Coming up with words "randomly" is, in fact, rather difficult psychologically. So various children sought and found various conceptual controls of their own. One is tempted to believe that the conceptual controls found by the children were somehow easier to use and sustain over time.

Some Hypotheses

Recently, Pascual-Leone (1970) has proposed a rather elegant quasi-mathematical scheme to account for the Piagetian transitions in cognitive development. He has proposed that children have an "M-space," a mental space, and that as children grow older their M-space can accommodate more and more schemes and process them together. One might argue that "high load" conceptual controls take up more M-space and "low load" conceptual controls less. One might argue that noise in the environment requires the use of part of the child's available M-space that thus, effectively, makes him "stupider."

As Pascual-Leone has set forth his argument, the notion of M-space is given as an abstract construct. One reasonable way to interpret such a construct would be to see it as a temporal duration, a fixed span of time during which coexisting associations, ideas, or schemes can be integrated together. If one argues that children become quicker at packing M-space as they grow older -- that they become quicker and quicker at coming up with a recognition, an association, a word, or an idea (White, 1970) -- then the Pascual-Leone theory would account for a good many of the relations between attention and cognition so far discussed.

Continuous increases in speed of ideation with age would lead, in the Pascual-Leone theory, to discontinuous, stagelike increments in the power of thought. At various points in development, the incremental process would bring integrally larger scheme-numbers into M-space and thus, "suddenly," thought would seem more powerful. One point of such "sudden" enlargement might be in the 5-7 age range.

Increases in speed of ideation could conceivably be developed by either maturation or learning. The usual index of maturation of various sectors of the brain is taken to be the completion of myelinization. Myelinization is known to produce speedier neural transmission and this could, quite conceivably, be associated with speedier ideational processes. Presumably, the broad patterns of Piagetian cognitive development are established by the postnatal embryology of the brain. However, it is a regular feature of learning experiments that training increases the speed of behavior. It would not be farfetched to believe that it increases speed of ideation. It would be quite conceivable in this scheme that localized training history could be found to accelerate or impede normative trends in cognitive development formed by normative maturational and training histories.

The correlation between neurological indices of maturation and conservation found by Gunnoe would find a straightforward explanation in such a scheme. It would be expected that children high on neurological negative signs would be relatively slow in processing relative to their peers.

The special problem-solving state explored in the Elias experiments would serve the function, for older children and adults, of tending to

conserve M-space by blocking out space-consuming distractors. Younger children, not forming such a state, would be expected to be much more vulnerable to capacity losses.

The trends studied in White and Mansfield (1969) and Mansfield (1970) would be rationalized within the Pascual-Leone theory. Noise would be expected to trade off against ability to deal with task complexity by a straightforward competition of noise-processing and problem-processing for limited-capacity M-space. Younger children, processing more slowly, would be expected to lose more M-space per distracting event than would older children.

Finally, with regard to the word association experiment just previously discussed, the basic issues of procedural control and conceptual control addressed by that experiment would appear to be interpretable within the model. That is, one could argue that the special procedures used in experiments with children are necessitated by their special vulnerability to the loss of M-space distraction. And when, in a somewhat "unshielded" word-association experiment, the children gravitated towards "lower load" conceptual controls this was because a relatively restricted M-space was available to them for direction of their strategies.

A quick sketch has been given of an analytic system for explanation of the mixture of cognitive and attentional issues addressed in the project's several efforts. The Pascual-Leone theory became available at the very end of the project work. Obviously, like any mathematical formulation, the theory will require much further development and attempts at substantiation. What is surprising and impressive is the ability of the formulation to bring into a consistent pattern a variety of data in this project, and a rather impressive amount of other existing data on cognitive development, speed of processing, and attention.

Summary and Conclusions

Research and literature analysis was undertaken to explore the interrelationships among learning, attention, and cognitive change in the 5-7 age range. Project work included: (1) Literature analysis of the body of Piagetian reports of cognitive change at the time of concrete operations; (2) Cross-sectional studies of the coincidence of various behavior changes in American schoolchildren as they move from the preschool to the early school years; (3) Studies of these same changes as they appear in African children living in urban schooled and rural unschooled environments; (4) Studies of these same changes as they appeared in a sample of first graders placed in a transition first grade class for "immature" children; (5) Studies of the developmental correlation between neurological indices and measures of Piagetian conservation; (6) Psychophysiological studies concerned with the hypothesis of a human problem-solving state emerging in development; (7) Studies of the interaction between noise-processing and problem-processing in children's learning; and (8) Experimentation and analysis concerned with the interaction between performance and competence factors in contributing to children's performance in experimental and testing games.

The body of work was designed in an effort to try to get a better overall picture of what appear to be some complex conceptual problems in formulating the kinds of interrelations that must exist between performance, competence, and developmental factors.

Major conclusions deriving from the work may be states as follows:

(1) One basis for the observed widespread pattern of changes in children in the 5-7 age range must be maturational. There is empirical substantiation supporting traditional notions of a developmental "readiness" for schooling.

(2) It is unlikely, however, that this readiness should be taken solely as a perceptual or cognitive kind of readiness. An important issue is readiness in terms of performance factors. A central performance issue is the question of the ability of the children to elaborate and sustain a program of behavior over time. This question is, probably, the kernel question in traditional notions about the importance of children's attention span.

(3) For a given problem, there is probably a tradeoff relationship between age of children's solving and amount of noise in the problem-field. The more the noise, the older the child has to be.

(4) For a given age, there is probably a tradeoff relationship between amount of noise in the problem-field and the complexity of problem that can be handled. The more complex the problem, the less the amount of noise that can be tolerated.

(5) The interrelationships among attention, cognition, and age envisaged in the course of this effort can probably all be subsumed in Pascual-Leone's recent formalization of Piagetian theory if: (1) his "M-space" and "schemes" are placed in a temporal rather than an abstract framework; and (2) it is assumed that noise-processing and problem-processing compete for the child's finite amount of M-space.

REFERENCES

Annett, M. The classification of instances of four common class concepts by children and adults. British Journal of Educational Psychology, 1959, 29, 223-236.

Aries, P. Centuries of childhood: A social history of family life. New York: Knopf, 1962.

Bender, M.B., Fink, M., and Green, M. Patterns in perception of simultaneous tests of face and hand. Archives of Neurology and Psychiatry, 1951, 66, 355.

Bloom, B.S. Stability and change in human characteristics. New York: Wiley, 1964.

Bousfield, W.A., Esterson, J., and Whitmarsh, G.A. A study of developmental changes in conceptual and perceptual associative behavior. Journal of Genetic Psychology, 1958, 92, 95-102.

Bronfenbrenner, U. Two worlds of childhood: U.S. and U.S.S.R. New York: Russell Sage, 1970.

Brown, L. Developmental differences in the effects of stimulus novelty on discrimination learning. Child Development, 1969, 40, 813-822.

Charlesworth, W.R. Development of the object concept: A methodological study. Paper read at American Psychological Association Convention, New York, September, 1966.

Chase, R.A., Sutton, S., First, D., and Zubin, J. A developmental study of changes in behavior under delayed auditory feedback. Journal of Genetic Psychology, 1961, 99, 101-112.

Elias, M.F. Heart rate, skin potential response, and latency of overt response,as indicators of problem recognition and solution. Psychonomic Science, 1970, 18, 337-339.

Elias, M.F. Three indicators of children's developing ability to recognize and solve complex problems. Unpublished doctoral dissertation, Harvard Graduate School of Education, 1971.

Elias, M.F., and White, S.H. Some psychophysiological and latency correlates of rule induction. Psychonomic Science, 1969, 16, 84-85.

Elliott, R. Physiological activity and performance: A comparison of kindergarten children with young adults. Psychological Monographs, 1964, 78, No. 10.

Elliott, R. Physiological activity and performance in children and adults: A two-year follow-up. Journal of Experimental Child Psychology, 1966, 4, 58-80.

Fink, M., and Bender, M.B. Perception of simultaneous tactile stimuli in normal children. Neurology, 1952, 3, 27.

Flavell, J.H. The developmental psychology of Jean Piaget. Princeton, N.J.: Van Nostrand, 1963.

Flavell, J.H., and Draguns, J. A microgenetic approach to perception and thought. Psychological Bulletin, 1957, 54, 197-217.

Germana, J. Psychophysiological correlates of conditioned response formation. Psychological Bulletin, 1968, 70, 105-114.

Gollin, E.S. Tactual form discrimination: A developmental comparison under conditions of spatial interference. Journal of Experimental Psychology, 1960, 60, 126-129.

Gollin, E.S. Tactual form discrimination: Developmental differences in the effects of training under conditions of spatial interference. Journal of Psychology, 1961, 51, 131-140.

Grim, P.F. Reaction time set effects and the GSR in relation to age and behavior ratings. Ph.D. dissertation, University of Chicago, 1965.

Hilgard, E.R., and Bower, G.H. Theories of learning. New York: Appleton-Century-Crofts, 1966.

Inhelder, B., and Piaget, J. The growth of logical thinking from childhood to adolescence. New York: Basic Books, 1958.

Jensen, A.R. How much can we boost IQ and scholastic achievement? Harvard Educational Review, 1969, 39, 1-123.

Kagan, S., and Madsen, M. Cooperation and competition of Mexican, Mexican American, and Anglo American children of two ages under four instructional sets. Developmental Psychology, 1970, 2, 122-126.

Kagan, S., and Madsen, M. Experimental analyses of cooperation and competition of Anglo American and Mexican American children. Developmental Psychology, 1971, 3, 188-192.

Kahneman, D., and Beatty, J. Pupillary responses in a pitch-discrimination task. Perception and Psychophysics, 1967, 2, 101-105.

Kendler, H.H., and Kendler, T.S. Vertical and horizontal processes in problem solving. Psychological Review, 1962, 69, 1-16.

Kohlberg, L. Stage and sequence: The cognitive-developmental approach to socialization. In D. Goslin (Ed.), Handbook of socialization theory and research. Chicago: Rand, McNally, 1969.

Koppitz, E.M. The Bender Gestalt test for children: A normative study. Journal of Clinical Psychology, 1970, 16, 432-435.

Kuenne, M.R. Experimental investigation of the relation of language to transposition behavior in young children. Journal of Experimental Psychology, 1946, 36, 471-490.

Levin, G.R., and Hamermesh, D.R. Procedure and instructions in kindergarteners' matching-to-sample. Psychonomic Science, 1967, 8, 429-430.

Lipsitt, L.P., and Serunian, S.A. Oddity problem learning in young children. Child Development, 1963, 34, 201-206.

Maccoby, E.E., and Konrad, K.W. The effect of preparatory set on selective listening: Developmental trends. Monographs of the Society for Research in Child Development, 1967, Serial No. 112.

Madsen, M. Developmental and cross cultural differences in the cooperative and competitive behavior of young children. Journal of Cross Cultural Psychology, 1970, 1, 225-229.

Madsen, M., and Shapira, A. Cooperative and competitive behavior of urban Afro-American, Anglo-American, Mexican, and Mexican Village children. Developmental Psychology, 1970, 3, 16-20.

Malmo, R.B. Physiological gradients and behavior. Psychological Bulletin, 1965, 64, 225-234.

McLaughlin, G.H. Psycho-logi[illegible]sible alternative to Piaget's formulation. British Journ[illegible] of Educational Psychology, 1963, 33, 61-67.

Milner, E. Human neural and behavioral development. Springfield, Ill.: Charles C. Thomas, 1967.

Nelson, L., and Madsen, M. Cooperation and competition in four-year-olds as a function of reward contingency and subculture. Developmental Psychology, 1969, 1, 340-344.

Olson, D.R. Cognitive development: The child's acquisition of diagonality. New York: Academic Press, 1970.

Osgood, C.E. Method and theory in experimental psychology. New York: Oxford, 1951.

Pascual-Leone, J. A mathematical model for the transition rule in Piaget's developmental stages. Acta Psychologica, 1970, 63, 301-345.

Piaget, J. The origins of intelligence in children. New York: Norton, 1952.

Piaget, J. Logic and psychology. New York: Basic Books, 1957.

Piaget, J. The psychology of intelligence. Paterson, N.J.: Littlefield, Adams, 1963.

Piaget, J. The construction of reality in the child. New York: Basic Books, 1954.

Piaget, J. The moral judgment of the child. New York: Collier, 1962.

Piaget, J. The child's conception of physical causality. Paterson, N.J.: Littlefield, Adams, 1960.

Piaget, J. The child's conception of the world. Paterson, N.J.: Littlefield, Adams, 1960.

Piaget, J. Judgment and reasoning in the child. Paterson, N.J.: Littlefield, Adams, 1960.

Piaget, J. The language and thought of the child. New York: Harcourt, Brace, 1926.

Piaget, J., and Inhelder, B. The child's conception of space. London: Routledge and Kegan Paul, 1963.

Piaget, J., Inhelder, B., and Szeminska, A. The child's conception of geometry. New York: Harper Torchbook, 1964.

Pick, H.L., Jr., and Pick, A.D. Sensory and perceptual development. In P.H. Mussen (Ed.), Carmichael's manual of child psychology, 3d ed. New York: Wiley, 1970.

Pratt, M. Changes in children's social conceptions in the years 5 to 8. Unpublished qualifying paper, Harvard Graduate School of Education, 1973.

Reese, H.W. Verbal mediation as a function of age level. Psychological Bulletin, 1962, 59, 502-509.

Shapira, A., and Madsen, M. Cooperative and competitive behavior of kibbutz and urban children in Israel. Child Development, 1969, 40, 610-617.

Stevenson, H.W. Learning in children. In P.H. Mussen (Ed.), Carmichael's manual of child psychology, 3d ed. New York: Wiley, 1970.

Stevenson, H.W. Children's learning. New York: Appleton-Century-Crofts, 1972.

Tanner, J.M. Physical growth. In P.H. Mussen (Ed.), Carmichael's manual of child psychology, 3d ed. New York: Wiley, 1970.

Terman, L.M., and Merrill, M.A. Stanford-Binet intelligence scale: Manual for the third revision. Boston: Houghton Mifflin, 1962.

Turnure, J.E. Children's reactions to distractors in learning situation: A developmental study. Proceedings of the 75th Annual Convention of the American Psychological Association, 1967, 167-168.

Vygotsky, L.F. Thought and language. Cambridge, Mass.: M.I.T., 1962.

Walk, R.D., and Saltz, E.J. Discrimination learning with varying numbers of positive and negative stimuli by children of different ages. Psychonomic Science, 1965, 2, 95-96.

Walters, R.H., and Parke, R.D. The role of the distance receptors in the development of social responsiveness. In L.P. Lipsitt & C.C. Spiker (Eds.) Advances in child development and behavior, 2d ed. New York: Academic Press, 1965.

Werner, H. The concept of development from a comparative and organismic point of view. In D.B. Harris (Ed.), The concept of development. Minneapolis: University of Minnesota, 1957.

White, S.H. Learning. In H.W. Stevenson (Ed.), Child psychology, 62d Yearbook of the National Society for the Study of Education, Part 1. Chicago: University of Chicago, 1963.

White, S.H. Evidence for a hierarchical arrangement of learning processes. In L.P. Lipsitt & C.C. Spiker (Eds.), Advances in child development and behavior, 2d ed. New York: Academic Press, 1965.

White, S.H. Age differences in reaction to stimulus variation. In O.J. Harvey (Ed.), Flexibility, adaptability, and creativity. New York: Springer, 1966.

White, S.H. Changes in learning processes in the preschool years. Paper presented at American Educational Research Association Convention, Chicago, 1968.

White, S.H. The learning theory tradition and child psychology. In P.H. Mussen (Ed.), Carmichael's manual of child psychology, 3d ed. New York: Wiley, 1970.

White, S.H. Some general outlines of the matrix of developmental changes between five and seven years. Bulletin of the Orton Society, 1970, 20, 41-57.

White, S.H., and Fishbein, H. Children's learning. In N. Talbot, J. Kagan, and L. Eisenberg (Eds.), Behavioral sciences in pediatrics. Philadelphia: Saunders, 1971.

Zeaman, D., and House, B.J. The role of attention in retardate discrimination learning. In N.R. Ellis (Ed.), Handbook of mental deficiency. New York: McGraw-Hill, 1963.